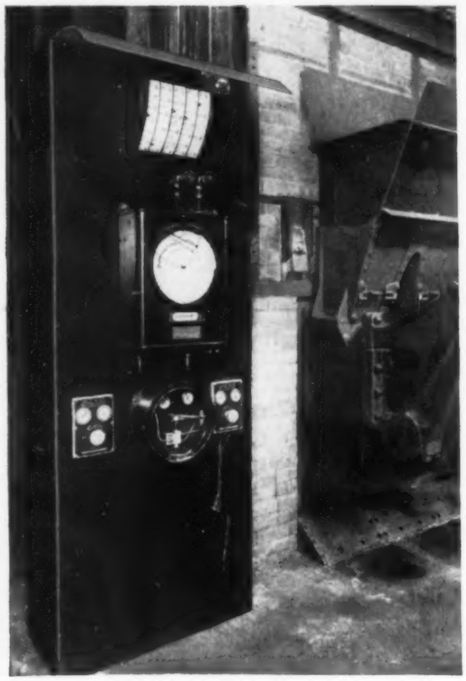

MECHANICAL ENGINEERING
February 1935
Robert Dudley Smith



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THE MATERIAL OF A THOUSAND USES

Volume 57
No. 2

MECHANICAL ENGINEERING

February
1935

GEORGE A. STETSON, *Editor*

Budgeting Effort

ANY ONE who has attempted to keep in touch with the advance of technological progress in mechanical engineering, to maintain a sense of perspective with regard to it, and to grasp the significance of similar progress in related fields of science, engineering, and economics has found the task a difficult if not an impossible one. Just as soon as we think that this progress is taking place along a certain portion of the frontier of knowledge, a prodigious sector in another portion forges ahead and demands equal or greater attention. Furthermore, with these unequal advances, the intervening areas suffer neglect.

As a result of this condition, an engineering society has an obligation to provide, in so far as it is able, the contacts, points of view, and sense of balance in the field of engineering that its members require and to obtain which they are organized. To this end the meetings, papers, committee activities, and publications of the society are chiefly dedicated. An examination of the development of these elements of an engineering society will show that while the natural specific interests of the individuals controlling them are likely to result in unbalanced emphasis and effort, the common purpose of increasing and disseminating knowledge in the field of engineering animates them all. However, because of their concern for the administrative factors of these interests, the individuals and the groups into which they are subdivided are likely to need some agency through which their efforts can be coordinated, and some related group whose attention is directed to the fundamental policies and programs of the Society as a whole. From such a group, it seems, would come a budgeting of effort.

In the newly constituted Advisory Board of Technology of The American Society of Mechanical Engineers (see the January issue, page 63) a group is set up to concern itself with the activities of the Society that have their origin in research, meetings, papers, and the fostering of the specific technologies, and end in publication. (A similar group is to be found in the New Advisory Board on Standards and Codes.) While the Advisory Board on Technology has been appointed and its chairman (Past-President A. A. Potter) named, it has held no meetings and hence has been unable to study its functions and tasks and announce its policy and program. However, from a reading of the duties of the Board as laid down by the Council in setting it up, coordination of existing activities and budgeting of Society effort to attain most effectively and efficiently the Society's objectives would seem to be paramount.

It must be borne in mind that the Board does not replace any existing committees, for years devoting their efforts to their assigned tasks, nor does it take over any of their functions. It is not an administrative group. Its task will be to give thoughtful study to the common problems of all the committees represented on it, to formulate policies for the consideration of these committees, and to advise them and the Council. Its work is going to be tremendously important, and its greatest contribution will be the possibility of an effective budgeting of effort.

Dispelling Fogs

LAST month we left New York in an atmospheric fog that tied up marine traffic to the tune of about a million dollars and journeyed to Washington where the intellectual fog of cross purposes, mixed opinions on underlying causes and consequent programs of action, and theories of social and economic problems in general is costing the taxpayers of the country several billions of dollars. As the ferry from Liberty Street to Jersey City groped its way amid the warning sounds of bells and whistles, we were quickened by the faint hope that some such adventure might befall as came to Thorne Smith's Bishop and his Jaegers, and by the more proper thought that, after all, there was a great deal of practical sense in the suggestion of Dr. Compton's Science Advisory Board that some of the New Deal's billions be spent on fundamental research in fog dispersion.

It seems, as Dr. Compton himself explains in the January 4 issue of *Science*, that "after a considerable discussion, Mr. Ickes said that he was 99 per cent convinced that something of the sort should be done (i.e., the research program proposed by the Board), but that there was, unfortunately, no provision under the law whereby public works funds could be expended for research but only for construction."

Imagine our amazement, therefore, on arriving in Washington and listening to the numerous representatives of the Administration, to find that earnest and well-intentioned planners had laid out programs for all sorts of social, economic, and engineering projects, most of which bore evidence of being the fruit of study, and all of which, to be effective and beneficial, will require the greatest amount of factual knowledge and intelligently

reasoned development and coordination. It appears that other planners of unemployment relief from whom the officers of the PWA derive their authority to disburse funds to stimulate recovery had estopped that agency from offering relief employment on these highly practical and promising tasks proposed by Dr. Compton's Board to scientists formerly on the staffs of governmental bureaus who were without jobs because still other planners had sought to cut down the regular expense of these bureaus, thinking that economy in governmental spending was a desirable objective in hard times. By this time it all seemed quite foggy, not only over the North River but on the banks of the Potomac as well, and some efforts at the dispersion of intellectual fog seemed to be indicated.

Subsequent reflection on one of those days when the atmosphere of New York is so clear that the sunlit tops of the skyscrapers stand out against the sky in an unbelievable brilliance developed the suspicion that men may carry about their heads, like an inglorious halo or a malevolent aura, a cloud of warped ideas and judgments which obscures not only their view of others but themselves as well. Dr. Compton's Board proposed the investigation of practicable ways whereby atmospheric fogs might be dispersed. Would it not also be well to devise some means by which we would not have to wait upon the fortuitous processes of intellectual meteorology to dispel the fogs of human understanding? We shall probably find a 99 per cent agreement on this proposition also, only to discover that there is no provision under the law whereby it may be undertaken.

If by spending a portion of Dr. Compton's asked-for 16 millions we could make ourselves masters of those terrifying blankets of fog that spread fear and disaster in harbor and airport, on the sea and in the air, we would remove one of the greatest and costliest hazards of marine and aerial transportation. And if equal success were to attend other researches, some of which were mentioned in the report, we might find much present planning made obsolete or even more effective. In the interests of planning it is too bad that some of the planners cannot find ways of stimulating scientific research and aid in the dispersion of the fog that obscures our knowledge of the universe in which we live.

A.E.C. Meeting in Washington

AT ITS recent meeting in Washington, the American Engineering Council made substantial progress in its ambition to become truly representative of the engineering profession and to speak authoritatively for engineers. Not for many years has so helpful and hopeful a spirit of real cooperation among engineering societies toward the attainment of these ends prevailed as characterized the 1935 meeting of the Council.

A new membership plan was ratified by means of which a great number of the 277 national, state, and local engineering societies, clubs, and councils that exist in this country will become members of A.E.C., thus establishing more firmly what Mr. Feiker, executive secretary of the Council, has happily termed the Washington Embassy of engineers. Increased financial support this year will make more effective the activities of the Embassy.

Provision was also made for the setting up of public-affairs committees in each state, to be made up of key men from local societies and sections, and correlated with the Council's committee.

An increase in the number and extent of pieces of legislation affecting engineers, an increase in the number of engineers in governmental employ and in the number of opportunities for engineering services under governmental direction, and an increase in the need for special engineering skill and knowledge in the regular activities of government, as well as in government-stimulated recovery programs, constitute a need for an effective "voice" in Washington. Far from acting merely to enhance the prestige and economic position of the engineer, the Washington Embassy provides for the government an official point of contact with individuals and groups in the engineering profession, able to offer advice on engineering matters, to suggest the names of persons with the necessary knowledge and talent to perform specific tasks or assemble needed information, and to bring to governmental agencies who are seeking them the right kinds of men to fill engineering jobs.

That the most cordial relations exist between Mr. Feiker and those in authority in Washington was evidenced by the remarkable array of important persons from the Administration's staffs who came before the Council to explain their particular tasks and points of view. Governor Eccles, of the Federal Reserve Board, M. L. Wilson, Assistant Secretary of Agriculture, Dr. Isador Lubin, of the Bureau of Labor Statistics, W. P. Witherow, Chairman, Industrial Advisory Board, NRA, R. E. W. Harrison, chief, machinery division, Bureau of Foreign and Domestic Commerce, Harlow S. Person, acting director, Water Resources Section, National Resources Board, Capt. R. S. Patton, director, U. S. Coast and Geodetic Survey, Col. Donald H. Sawyer, director, Federal Employment Stabilization Office, Thomas Hibben, chief engineer, FERA, Clarence McDonough, chief of the engineering division, PWA, and Charles C. Anthony, industrial advisor, FHA, addressed the meeting. At the A.E.C. dinner, attended by more than 400 engineers, Dr. Harold G. Moulton, president, Brookings Institution, spoke on his study of America's capacity to produce and to consume.

Following such varied and solid fare, it is not strange, although no fault of those who made the presentations, that a clear, logical, and properly coordinated conception of what is going on at Washington should elude many of those who listened. Reconciliation of the theories advanced by some with those advanced by others, with those to which many listeners were more familiar, and with the objects and realities of the recovery effort was not always easy or possible. Some speakers dealt solely with matters affecting technical programs and hence did not attempt much in the way of economic or social justification. Some, with cold and apparently precise logic,

developed philosophies whose validity must thus rest upon the correctness of their premises. Still others, a not too encouraging minority, expressed with admirable humility and intellectual integrity their inability to make all of their views airtight and dogmatic, expressing honest doubts about some of the implications of their theories. But it was all very stimulating; and Mr. Feiker is to be congratulated, not only for the array of talent that he assembled, but also for the clockwork precision with which his program ran.

We sincerely regret that every reader of MECHANICAL ENGINEERING did not have the privilege of coming under the influence of these stimulating speakers. The experience was educative, provided much food for thought, raised many annoying problems and honest doubts, and should have made more humble the arrogantly dogmatic.

George M. Bond

THOSE whose interests lie in the encouragement of youthful graduates of our technical schools will find much to serve their purposes in the life of George M. Bond, recently deceased. It was during his senior year at Stevens Institute that Mr. Bond, in 1879, under the direction of Prof. James E. Denton, of Stevens, and Prof. William A. Rogers, astronomer, of Harvard, designed the famous Rogers-Bond comparator, subsequently built under his direction at the Pratt and Whitney Company, Hartford, Conn., and used to carry out some of the first work in establishing standards of precision in the manufacture of gages by that company. As an appropriate sequel to this early work, from the year of his graduation in 1880 until 1902 Mr. Bond was manager of the standard and gage department of Pratt and Whitney, and under his direction the company produced its line of precision and manufacturing gages.

The work of George Bond and his associates forms an important chapter in the history of mass production in this country, made possible by the introduction of multiple-parts manufacturing by the gun makers of Connecticut, Whitney and North. Gaging was an essential element of sound progress which that other Connecticut manufacturer, Colt, developed so successfully; and with the advance that came in attempting to attain more certainly and more cheaply the economic and practical benefits of mass production, the necessity for precision gages became more and more apparent. Such standards of quality in workmanship developed in and around Hartford industries that have become famous for their products, processes, and workmen. Thus here, from time to time, as the changing fortunes of manufacturing have given birth to them, there grew up the manufacture of articles in which quality workmanship and precision became more and more essential—the machine tool, the typewriter, the bicycle, the motor car, and, in recent years, the aircraft motor.

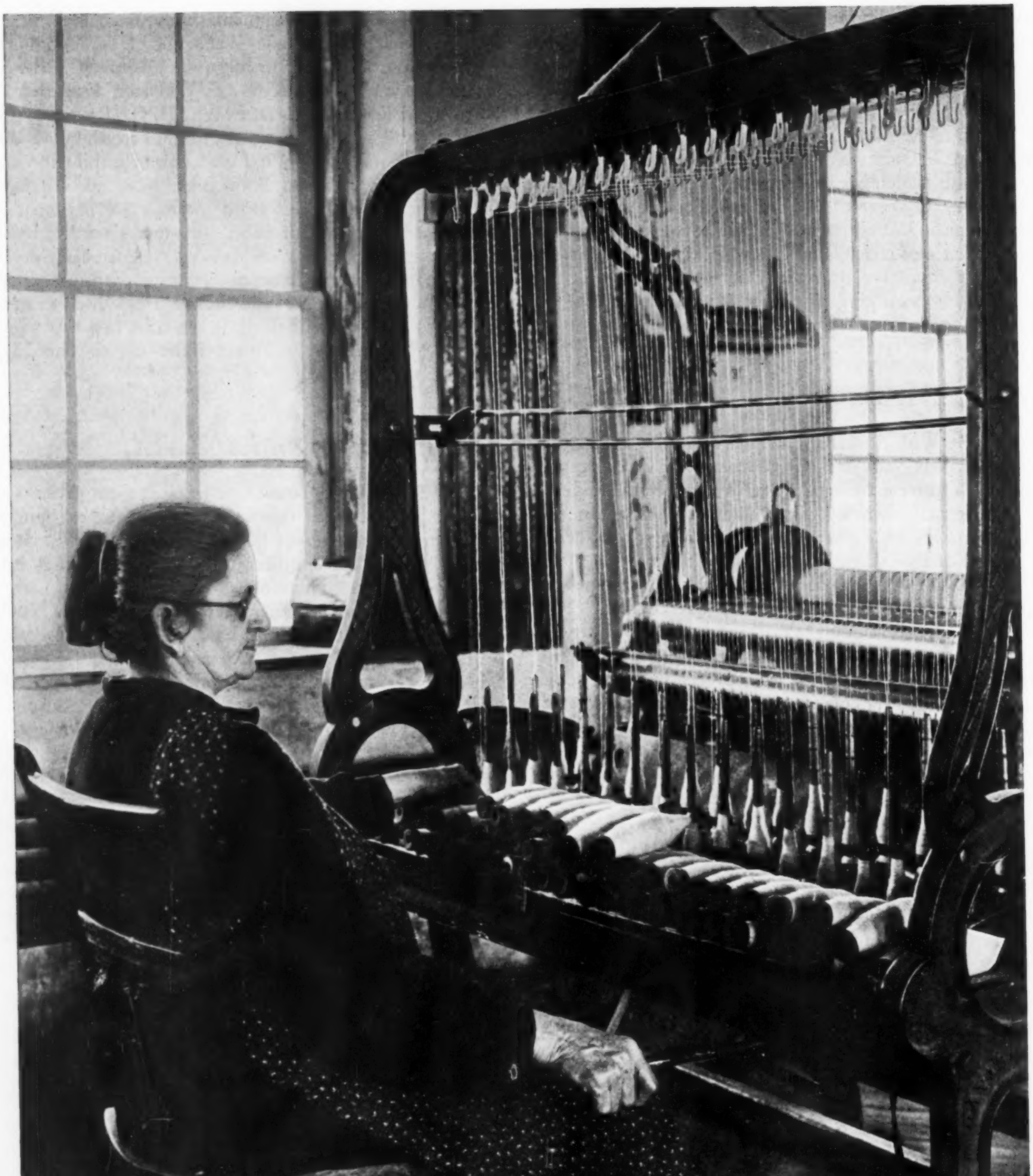
Mr. Bond read his first paper before the A.S.M.E. on May 4, 1881, at the meeting in Hartford. Among those present—what a category of worthies that list was!—were Robert H. Thurston, Oberlin Smith, J. Sellers Bancroft, Charles E. Billings, Charles E. Emergy, Gustavus C. Henning, Alexander Lyman Holley, Francis A. Pratt, Charles B. Richards, Samuel Webber, C. J. H. Woodbury, Prof. George J. Alden, Lycurgus B. Moore, Charles P. Deane, Jerome Wheelock, H. F. J. Porter, Frederick R. Hutton, A. R. Wolff, E. D. Leavitt, J. C. Hoadley, Alan Stirling, and many others, not a numerous but a distinguished company. What a wealth of inspiration and experience the youthful Bond must have derived from these contacts! and with what justifiable pride must he have heard the president of his alma mater say: "I think it is the first time in which accurate, scientifically determined standard measurements have ever been introduced into commercial work of the character of which most of our shops are doing. I think it is a start in a new direction. . . . ." George M. Bond lived up to the high promise of this praise.

The Engineer and the SEC

IN ATTEMPTING to remove hazards from those who invest in securities offered for sale on the exchanges, the Securities Act of 1933 has measurably added to those in the path of the engineer whose practice brings him within its scope. Therefore, W. W. Colpitts, of Coverdale and Colpitts, consulting engineers, of New York, has done all engineers a considerable service in presenting in the January, 1935, issue of *Civil Engineering*, a digest of the Act as it affects engineers, and his comment on the Act as applied to engineers. (Reprints of Mr. Colpitts' study may be obtained from the American Society of Civil Engineers at 25 cents per copy.)

Mr. Colpitts' comments are made in the sober and judicial manner which, we imagine, the Securities and Exchange Commission expects engineers to use in making engineering reports. He points out what seem to him to be extremely serious and far-reaching responsibilities that the engineer assumes under the Act. And in consideration of these, which he makes very clear, he concludes as follows:

> A close study of the Act leads to the conclusion that the engineer is not placed in jeopardy by the Act because of any presumption of habits of exaggeration, looseness of statement, or willful misrepresentation. His tendency has been distinctly in the opposite direction. In the light of the provisions of the Act it can be said, however, that in the future the engineer cannot rely too much upon his reputation as an authority, but must give his clients and the public the full sources of his facts and the complete reasons for his opinions.
>
> Due to his fallibility, and to his inability to determine out of the great mass of data he may collect what should be set forth in his reports and what should be omitted, and perhaps to his own personal equation, the engineer is now subjected to hazards in the practice of his profession to which he is unaccustomed, and he must adjust himself to the new order.
>
> In view of the position which these aspects of the law present it would appear that the fees charged by engineers must be regulated in accordance with the responsibilities they must now assume.



Young-Phelps

A Typical Woolen Worker in the Cooperative Mills of the Amana Society, Iowa

LABOR-MANAGEMENT *Cooperation* *in* METHODS DEVELOPMENT

Some Conclusions From the Experience of the Pequot Mills

By RICHMOND C. NYMAN

INSTITUTE OF HUMAN RELATIONS, YALE UNIVERSITY

HOW AND to what extent can management and labor cooperate to introduce labor-saving changes? This problem is of increasing concern to managers, engineers, and labor leaders under present industrial conditions. Yet no wholly satisfactory solution of it has been found. The experience of the Pequot Mills, however, provides noteworthy evidence as to certain aspects of solution.[1]

Five years ago the management and labor union at this cotton mill entered into a plan for union-management cooperation in reducing production costs. Under this plan, mill and union, working together, succeeded in installing the so-called multiple-loom or extended-labor system.[2] This system was a means of reducing production costs by improving mill-operating conditions and by adjusting and extending worker job assignments. It had already been widely introduced in cotton manufacturing. Its general introduction, however, had stirred up so much antagonism and its labor consequences had been such that it had become known among textile workers as "the stretchout"—this term implying that it was a plan for "stretching out" job assignments to the limit of a worker's strength or capacity or beyond.

THE COOPERATIVE LABOR-SAVING PLAN

Union-management cooperation in labor saving at the Pequot Mills grew out of a serious controversy over how much additional work the management could rightly ask the workers to do. During 1928, increasingly adverse competitive conditions made cost reductions, particularly labor-cost reductions, imperative at the Pequot Mills. The management decided that costs could best be reduced by installing the "stretchout" system and that this was justified by labor-saving improvements which had previously been made and by the exceptionally good manufacturing and working conditions provided at the mills. Plans for a series of definite increases in worker job assignments throughout the mill, based primarily upon the trade knowledge of the mill operating executives, were accordingly prepared.

These plans were submitted to the officials of the labor union with a request for worker acceptance and cooperation. At a union meeting the union officials carefully explained the circumstances and informed the workers that the management had promised that adjustments in tasks and wages would be made to compensate them for accepting the proposed increases in their job assignments. The workers, however, flatly refused to accept the "stretchouts" and threatened to strike if the management attempted to put them into effect.

This action created a deadlock which threatened to destroy a general plan of union-management cooperation which for two years had proved a successful basis for industrial relations at the Pequot Mills. Fortunately, this plan, which had been adopted at the suggestion of the union, had given the union leaders an unusual appreciation of the management problems and labor-relations issues involved in the dispute. It had likewise given the mill officials an unusual degree of confidence in the union leaders. Fortunately, also, this plan pledged the workers to support management efforts to effect "economies in manufacturing."

The union officials realized that the workers' refusal to accept the "stretchouts" put this plan of union-management cooperation to a severe test. They saw, however, that the fundamental issue was not whether the "stretchouts" should be made but that whether they would overburden the workers and cause unnecessary loss of pay or job. Instead of ordering a strike, therefore, they succeeded in contriving a plan for cooperative control of the "stretchout" which met with general approval.

The plan was this: A bi-partizan joint research committee of mill and union executives and a bi-partizan joint research staff under the direction of the committee and the supervision of a non-partizan technician were to be organized. These were to be responsible, respectively, for determining how much additional work could rightly be assigned to the workers and for ascertaining by systematic job analyses the objective facts as to existing mill operating conditions and worker performance which would indicate this. A procedure of joint factual investigation and joint consideration and decision was thus provided for. No "stretchout" could be made until first subjected to joint investigation and then joint approval.

The plan worked effectively as an instrument of joint judicial control. The slow and complicated but thorough and technically sound joint research procedure produced "stretchouts" throughout the mill which were mutually acceptable to all concerned. Working together the bi-partizan members of the cooperative research staff conducted a series of time studies, job analyses, and trial runs, and from the facts thus obtained developed new job standards. As these studies progressed the job or machine assignments of the workers were gradually increased until it was agreed that a fair limit of labor extension had been reached. In each case the facts as to this were then reported to the joint research committee and substituted for subjective opinion in reaching agreements as to what increases in job assignments should be made.

"Stretchouts" thus decided upon were then referred to the mill and union officials for final acceptance and for decision as to the wage rates to be paid and other details of installation. When finally accepted, the labor extensions were carefully

[1] The mills of the Naumkeag Steam Cotton Company, Salem, Mass. For a full account of the labor-management cooperation experience of the Pequot Mills, see "Union-Management Cooperation in the Stretchout," by the author of this article in collaboration with Prof. Elliott Dunlap Smith, Yale University Press, December, 1934.

[2] For a description of the "stretchout" and some tentative findings concerning its general introduction and significance, see "Lessons of the Stretchout," by Professor Smith, Mechanical Engineering, February, 1934.

installed under the combined supervision of the joint research staff, the mill operating executives, and the union departmental delegates. Working together, the delegates informed the workers involved of their new job assignments, changes of status, or discharge, and with the members of the joint research staff trained the "extended" workers in the performance of their new duties.

CONTROL REQUIRES STANDARDIZATION

The first joint research studies were made in February, 1929. These unexpectedly revealed that there was too much fluctuation in mill operating conditions and that operating practices were too varied to permit labor extensions to be made with any certainty that they would be fair either to the company or the workers, even if based upon careful job analyses. The technician in charge of joint research accordingly decided that if his staff were to follow sound engineering practice, it should first endeavor to improve and standardize mill operating conditions and management practices and techniques.

That this was a proper function for joint research was indicated not only by the circumstances but also by the cooperative cost-reduction plan itself. One of the supplementary provisions of the plan pledged the management to undertake "master planning" so as better to coordinate sales and production. Another stated that the joint research committee should "devise methods of cooperation for the elimination of waste and the improvement of working conditions." Just what was meant by "master planning" and what procedure should be employed to develop means of eliminating waste were not, however, precisely stated. These had been left for future consideration or for decision in process, since they were not at first seen as essential to the adjustment of the labor-extension dispute.

Perhaps more important, the mill and union officials, in adopting joint research, had not sought methods development as such. They had adopted it primarily to solve the impasse as to present cost reductions and to show what "stretchouts" could be made under existing operating conditions. It seemed to them that to plunge into methods development first would only complicate and retard the solution of the urgent problem of what labor extensions could be made. On this account they declined to lend the support of their authority to this work although they permitted the technician to proceed as he thought best. The extent to which new methods might be introduced was thus made dependent upon the ability of the joint research staff to educate or persuade the minor executives and workers to accept changes in their accustomed ways.

METHODS DEVELOPMENT LEADS TO NEW CONFLICT

This placed joint research in a new light. As a result of the unexpected need for methods development the settlement of the fundamental issue of the "stretchout" and the position of joint research remained in doubt for many months. Inevitably, troublesome questions arose as to the precise relationship of joint research to management and as to how its participation in methods development affected its ability to represent and protect labor. Moreover, actual labor extension was delayed for so long and methods development proved so disturbing to the status quo that the cooperative cost-reduction plan began to lose favor.

Starting in February, 1929, joint research endeavored for more than a year to determine and provide such operating conditions as it felt were essential to permit the largest possible degree of labor extension while giving the workers maximum protection. Much progress was made in the improvement and standardization of mechanical operating efficiency. Some preliminary job analyses were prepared. Numerous new operating methods were devised. But the joint research staff found it all but impossible to persuade either the minor executives or the workers to put these into effective use.

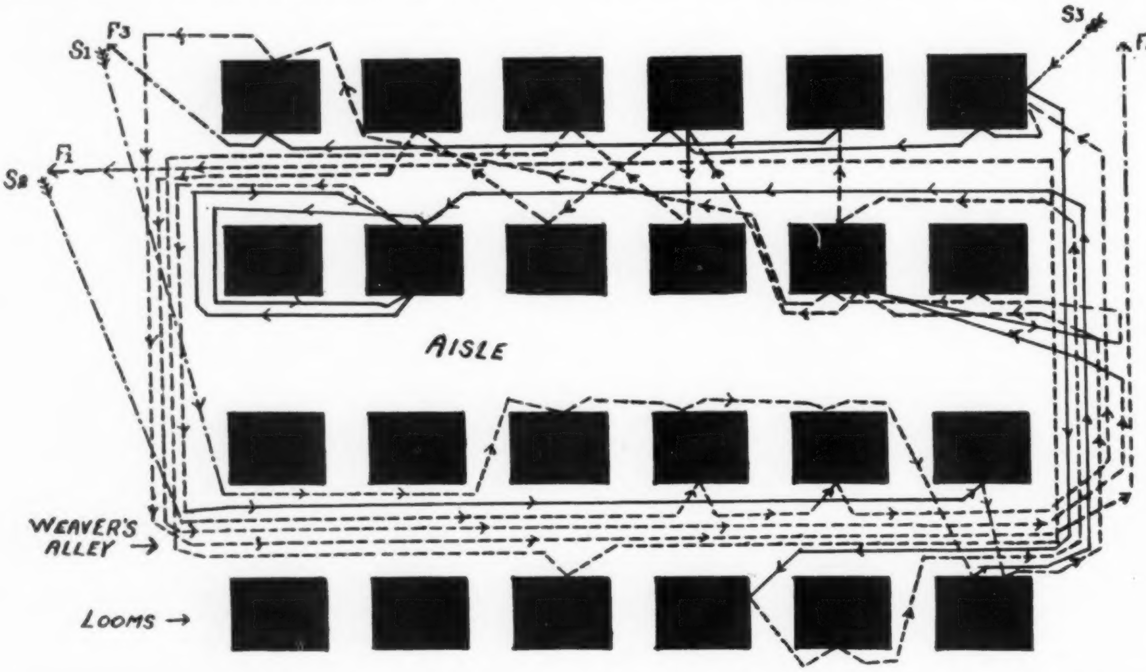


FIG. 1 DIAGRAM SHOWING WEAVER'S PATROL PRIOR TO THE INTRODUCTION OF THE MULTIPLE LOOM OR SO-CALLED "STRETCHOUT" IN A PRINT-CLOTH MILL

(It was to systematize the work of the weaver that the system was first installed. A 20-minute patrol of an assignment of 24 looms is shown, the solid lines indicating skilled work and the broken lines indicating unskilled work being performed. In the mill from which the diagram was obtained the weaver's assignment was increased to 75 looms when his unskilled tasks were assigned to supplementary workers and his patrol systematized.)

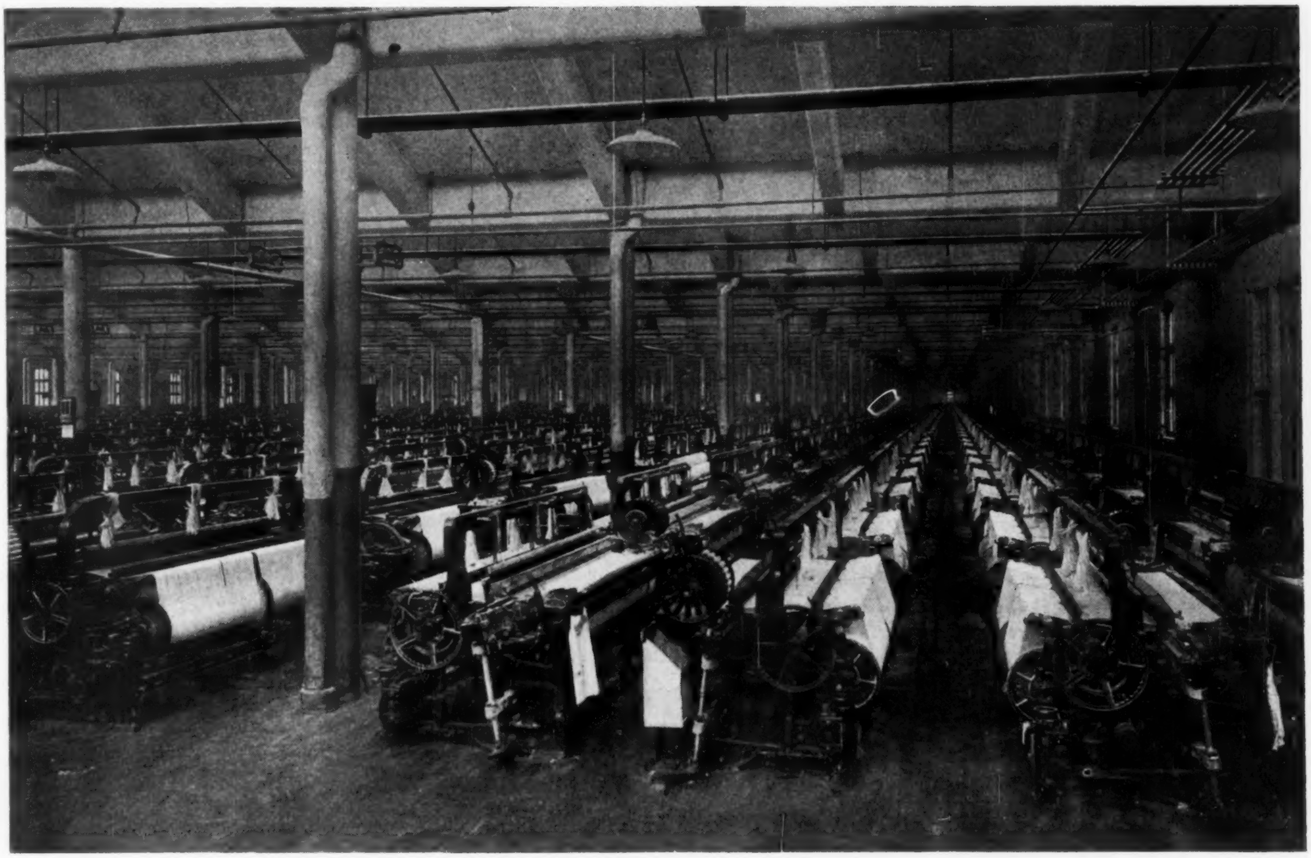


FIG. 2 THE PEQUOT MILLS WEAVE ROOM

In so far as joint research was confined to the determination of facts to show how far existing conditions permitted labor extension, it enlisted cooperation. But whenever joint research sought to determine what conditions *should be*, instead of what conditions *existed*, and to *provide* those conditions, it encountered concerted resistance.

No basic changes had been made in the workers' jobs or in the management practices of the minor executives for more than a decade. Yet the mill had prospered. Hence it was difficult for both managers and workers to see the development of complex technological methods as essential to labor extension. Both, therefore, conscientiously believed that joint-research methods-development work was little but an unwarranted disturbance of the ways and conditions to which they had so long been accustomed. It was one thing, both realized, to control the adjustment of work loads to existing conditions or agreed upon labor-saving changes, but quite another matter to carry labor saving forward beyond this.

Also, when joint research began to devise and to attempt to install new labor-saving techniques, the minor executives, despite the long friendly union-management relations, began to question the right of union representatives to initiate such changes. On their part, the workers began to ask themselves whether they were sharing in restraint or whether the cooperative cost-reduction staff was merely expediting labor extension. This also prompted them to question whether the union leaders were really controlling the "stretchout," and to wonder, despite the confidence which they had long held in their representatives, whether they were not becoming instruments of management control.

Hence, while joint research was successfully bringing workers and management into a common understanding of how far the proposed labor extensions should go, it met with resistance from both. On the one hand it was encountering serious opposition from both in its efforts to support these labor extensions by technological standardization and by what seemed to them as placing encumbrances on common-sense management through the installation of unnecessary routines of control. On the other hand, joint research was beginning to encounter opposition from labor in so far as it was seemingly attempting to introduce new labor-saving techniques which might well lead to larger labor extensions than had been contemplated, and which might defeat what was to the workers its major purpose of restraint.

RESEARCH PROVIDES BASIS FOR AGREEMENT

This situation, however, was not permitted to become serious. Sensing that confidence in joint research was waning and that a basis for a common agreement had been laid by the research work already done, the union's business agent decided that action on the "stretchout" should no longer be deferred. He therefore cut through all of the problems as to the position and proper function of joint research by a bold stroke. Out of a clear sky he abruptly proposed a compromise "stretchout" in weaving, a department of the mill where it was estimated that labor extension would yield the greatest amount of cost reduction but where it had also been expected that the greatest difficulty would be encountered in increasing job assignments.

He succeeded in persuading the mill officials that action upon the weaving labor extensions should not wait for further research study. As a result a "stretchout" was negotiated which was sufficiently large to gratify the management and yet

sufficiently smaller than that originally planned for weaving to satisfy the workers.[3] This weaving "stretchout" was installed between May and July, 1930, after nearly a year and a half of joint research. The results were so satisfactory as to restore confidence in joint research to an extent enabling it to carry the proposed labor extensions through the rest of the mill.

INITIAL RESULTS EXCEPTIONALLY FAVORABLE

The results of these initial labor extensions were generally favorable. The labor-saving changes brought about increases in job assignments acceptable alike to management, union, and workers. Appreciable cost reductions were made, the labor extensions yielding an annual saving in labor expense of approximately $200,000. At the same time average wages were increased by nearly 15 per cent. Both operating and working conditions were improved. Although some demotions, which were expected to be temporary, could not be avoided, loss of jobs by regularly employed workers was held to a minimum. Moreover, these results were achieved in the midst of the depression and in spite of the fact that during this period in the industry, generally, the labor effects of the "stretchout" became so adverse as to make it a major issue of the recent general strike in textiles.

Admittedly, bargaining had intervened to bring about action. The cooperative cost-reduction plan, however, had undeniably provided the facts essential to the weaving agreement. Based upon these the weaving-labor extensions had been installed with general satisfaction and had convinced the workers that joint research could protect them by controlling the degree of labor extension. This, and subsequently the success of the initial labor extensions elsewhere in the mill, also led the mill and union officials to regard joint research as a permanent institution for maintaining cooperative relations between the company and its workers. Both gave it support thereafter.

JOINT CONTROL VS. JOINT INITIATIVE

Union-management cooperation in labor saving, however, had solved only one of two fundamental problems involved in cost reduction at the Pequot Mills. It had served effectively to control the labor extensions demanded by the management. But besides this, in so far as the plan was made permanent, there was also the problem of developing new ways of increasing operating efficiency and of saving labor to be faced. Once joint research was considered as being at all permanent, the question of its initiation of new labor-saving methods, which had been troublesome from the first, became a vital issue.

Even before the first "stretchouts" were accomplished the workers had begun to question whether joint research had any place in devising labor savings that might cost some of them their jobs. Partly, this was the resistance of seasoned workers against what they considered new-fangled ideas. More and more it now became a fear that they had drifted into a position where their own representatives were becoming agents in increasing their tasks and reducing the number of jobs.

The growth of this suspicion was furthered by the fact that after the first interest in the "stretchout" compromise and installation was over, the labor extensions began to cause discontent. Soon the average worker tended to overlook what he had gained and to see more clearly what he had lost. Numerous demotions of skilled workers to much lower paid unskilled jobs had proved unavoidable. Upward of 250 temporary workers had been eliminated, making it clear that further labor saving would cut into the jobs of those regularly employed. Hence, fear of demotion and unemployment reasserted itself.

In addition the fear that labor saving would lead to excessive job burdens was kept alive and restimulated. Continued operation on the "extended" basis began to result in unexpected strains. Difficulties not apparent in the first few months began to be felt. On the level of practical operation some of the workers found the working methods established by joint research overly rigid. The more highly standardized and larger job assignments were not supported by equally standardized or systematic methods of control and materials supply. This necessitated practical adjustments which tended to undermine the basic job standards. As a result, the workers came to believe that their jobs were not only larger but harder and to attribute this to joint research.

Thus as time wore on and as the permanent place of joint research in initiating labor savings became more clear, the fears of the workers that this gave rise to were heightened by their feeling that the results of the first labor extensions left much to be desired.

It is impossible to say just how serious a problem this situation would have created in itself, for as time went on it was more and more overshadowed by the influences of the depression. All of the unfavorable consequences and adverse influences of labor extension and joint research were colored and magnified by the hard times.

ADVERSE INFLUENCES AND COMPLICATIONS OF DEPRESSION

During 1931, the depression made it all but impossible to promote or reinstate very many of the displaced workers while otherwise many of those demoted could soon have been returned to their higher skilled jobs and many who were laid off could have been taken back. In normal times such great gains as had been made would probably not have been followed by immediate demands for further extensions. But the depression created a need for cost reduction even greater than the appreciable savings of joint research had produced before the initial "stretchouts" had been fully completed.

In November, 1931, the management had to curtail mill operation, and in January, 1932, wages had to be reduced. During the next few months, the depression still further tightened its grip on the industry. Although Pequot was perhaps less seriously affected than some other mills, the management was again obliged to curtail operations, and in May, 1932, had to demand the acceptance of another wage reduction and further labor extensions.

EDUCATION AND UNDERSTANDING ESSENTIAL TO COOPERATION

The workers, however, had little appreciation or understanding of how much the sacrifices demanded of them arose from the problems created by the depression for management and union or of the real position and purposes of the union leaders. They saw only that joint research and labor extension led to heavy job burdens, reduced wages, and loss of jobs.

The joint-research plan clearly faced the fact that the acceptance of the results of joint research work depended much upon workers' understanding of the merits of its findings. It accordingly provided for direct participation in the joint-research studies and committee meetings by the individual workers directly affected by any labor extension. It also required the

[3] The Pequot weave room was equipped with 4047 modern automatic looms, manned by 589 workers, of whom 306 were weavers. The management originally asked the weavers to operate an average of 24 instead of 13 looms each. Tentative joint research findings indicated that the average number of looms per weaver could be increased to 20 without overburdening the workers. The "stretchout" was made on this basis, although the maximum degree of labor extension possible was still uncertain. It reduced the total number of workers required to 433, the number of weavers to 183, reduced labor costs by nearly 20 per cent, and raised average wages by about 15 per cent. While more than 100 jobs were eliminated, discharges were confined to employees who had been hired on a temporary basis in anticipation of the change.

posting of reports of the joint-research activities throughout the mill to keep all of the workers informed. These educational provisions proved effective in gaining worker acceptance of the specific labor extensions but not in bringing the great mass of the workers to appreciate the broader purposes and problems of cooperative labor saving sufficiently to gain their approval of such things as its participation in methods development.

More important, both the joint-research and union-management cooperation plans limited labor participation in joint discussions of management problems to the officials of the union. A similar centralization of discussion was true even within the union, since for years the business agent and a small executive board had been in full charge of union affairs and in almost isolated contact with the management. The workers generally learned of either management or union problems only after policies or actions were already decided upon or were to be put to a vote at union meetings. Since meetings of the union were seldom attended by more than one hundred workers, although nearly all of the 1800 employed were members of it, even here but few were brought into direct contact with union or joint union-management affairs.[4]

WORKER CONFIDENCE IN LABOR LEADERS ESSENTIAL

In consequence, the growth of worker opposition to joint research was accompanied by a loss of confidence in the union leaders. Throughout, the union officials had been in close association with the mill executives but had come into direct contact with the workers as a group only at union meetings. As a result their staunch support of joint research and repeated presentation of management demands requiring concessions from labor were misconstrued. Worker confidence in the union leaders, despite their long, effective management of union affairs, was displaced by mistrust which grew into a conviction that they had deserted the cause of labor.

This placed the union officials in an almost hopeless position from which they found it impossible to withdraw. Joint research had been grasped by the workers, not only as a symbol of hardship but of union duplicity. The unfavorable effects of the labor extensions and of the depression had increasingly stirred up resentment and fears which could not be allayed. These circumstances required the union leaders to maintain cooperative relations and control more than ever, but without worker confidence this was impossible. From the time of the second wage reduction, which went into effect in July, 1932, until May, 1933, when the joint research and union-management cooperation plans came to an end, the mill and union officials were obliged to deal not only with a rebellious group of workers but also with a rebellious union electorate.

Thus union-management cooperation not only had to contend with the difficulties inevitably involved in installing and maintaining any labor-saving changes but also to carry the burdens of an unprecedented depression that made it necessary to pile demand upon demand, with no opportunity for gaining compensating concessions from management to offset the sacrifices required of labor. But these very factors make especially clear the importance of providing for two things in any enduring cooperative labor-saving plan. Seemingly, it is of fundamental importance to keep the workers closely and widely in touch with general management problems and general union-management relations. It is also of great importance, apparently, to bring the workers sufficient understanding of the participation of the labor leaders in management problems so that they recognize that their leaders in working with management are not failing to represent labor.

In the Pequot experience all of these factors and developments emphasized more clearly the difficulties of carrying forward joint research on a permanent basis and of using it to initiate new labor-saving changes. By the time of the first wage reduction, for example, joint research had become so subject to worker distrust that the management and union, recognizing that its abolition would somewhat compensate for this new sacrifice, agreed to discontinue it. How true this was was indicated when the second wage reduction and the reinstatement of joint research was proposed a few months later. By this time joint research stood so discredited in the eyes of the workers that they voted overwhelmingly against accepting more "research on their jobs" and to strike rather than accept both this and another wage reduction.

As a result of this vote, the management agreed to postpone further joint research. The depression, however, continued relentlessly to make further cost reductions more imperative than ever. In consequence, within a year the management, unwilling to reduce wages again except as a last resort, again proposed a resumption of joint research and labor extension.

This proposal was made in March, 1933, at the very depth of the depression. The union officials appreciated not only the management's need but also how deeply intrenched and widespread worker antagonism toward joint research had become. Nevertheless, when an investigation convinced them that the new "stretchout" demands were on the whole reasonable and certainly preferable to another wage reduction, they consented to place them before the workers. By this time, however, the workers looked upon cooperative labor saving so much as a means of exploitation connived in by their own leaders that the union officials were helpless. Nothing that they could do would make the workers agree to further joint research or labor extension. Instead, they launched against it a furious counter attack and for three months preferred to endure the hazards and hardships of a strike rather than yield.

The workers returned to their jobs only when the management agreed that no labor-extension research would take place for two years. Even then they would not return to the union or again accept the leadership whose cooperative plans had, in the distorting shadow of the depression, taken on the color of management tools. This brought to an untimely end the sincere and courageous efforts of the representatives of labor and management at the Pequot Mills to work together.

This struggle of management and union to work together throughout the depression in meeting its problems by cooperative labor saving, however, gives vivid emphasis to certain aspects of the problem. It brings out strikingly how normally difficult problems are intensified and complicated by hard times. It makes clear that in carrying forward labor saving beyond adjustments to existing conditions and the control of existing demands the difficulties of cooperation are greatly increased. This raises the question of whether any plan of cooperation in labor saving should do more than pass upon the extent to which changes discovered and initiated by management permit job assignments or requirements of the workers to be increased.

The Pequot experience also indicates strongly that regardless of function or purpose it is important in any cooperative plan that provisions should be made not only for local participation but for general understanding of the general problems of management and of how both workers and labor leaders are to share in the solution of those problems. Above all it demonstrates that, given the sincerity and integrity which characterized both sides at Pequot, cooperative action can go a long way toward solving both the problems of reducing costs and of protecting the interests of labor in the process.

[4] The only workers not members of the mill union were the loom fixers, a small but highly skilled and influential group, who had their own union.

The AUTOMOBILE *of* 1935

THE New York Automobile Show of the first week of January was a success from an engineering point of view. If it proves to be as much of a commercial success as was claimed for it by the exhibitors, one cannot help but feel that this was entirely deserved.

Without attempting to describe in detail every improvement incorporated into the automobile of 1935, attention may be called to the following features.

Judging by the fact that no other maker has attempted in the 1935 car to carry streamlining to the point incorporated in the two Airflow Chrysler cars, it would appear that, in the judgment of the industry, the public has accepted extreme streamlining to a moderate degree only. This is still further evidenced by the fact that the Chrysler Company, in addition to the two streamlined Airflow cars, is selling a type in which streamlining is used moderately (Airstream models). Nevertheless, attempts to attain a streamlined appearance, and as far as possible, performance, are not lacking. Nash frankly specifies no angular surfaces or pockets to retard the car—not even a spare tire on the rear—just a long sweeping curve. Several other cars have concealed the spare tire in a compartment located in the fishtail rear end. All of them, however, leave the headlights just where they always were, although there is a tendency to give the headlights the boat-bullet shape.

One or two cars show extremely developed fenders and nearly all have narrow, tall radiators. These latter must have given a good deal of anxiety to design engineers, as the narrow, tall radiator is comparatively difficult to cool.

One of the best examples of incorporating the general flow line, otherwise known as streamlining, without producing an unconventional effect is given by the Pontiac.

The Reo retains its automatic gear shift. Hudson has introduced both in the Hudson and in the Terraplane an electro-vacuum shift controlled by buttons on the steering column. The Lafayette has a synchro-shift type of transmission with silent helical gears constantly meshed, and a bronze clutch arrangement for synchronizing gear speeds to provide silent shift. Several cars have changed the shape of the gear-shift lever to give more leg room and particularly to increase the seating capacity of the front seat. This was unquestionably brought about by the specter of the "gearshiftless" car.

It is not at all surprising that, with 36,000 persons killed last year in automobile accidents and more than 1,000,000 injured, safety should receive special consideration, particularly in view of the growing tendency toward speed as expressed in the advertising of several automobile companies promising speeds of 90 and even 100 mph. This trend to greater safety has found expression in the extension of the use of hydraulic brakes, in the use of larger brakes, and in heavier and stronger bodies. In fact, at no other show have frame construction and the body's ability to take punishment been so well advertised. In this connection, the "turret top" of General Motors is to be noted, and provides, for mechanical engineers, evidence of much study by designers and production men.

The comfort feature has also received increasing consideration. Several cars have now abandoned the conventional positions of the rear seat and engine and have shifted both forward, with the result that greater comfort for the rear-seat passengers has been secured. The poising of both the front and rear seats between the springs and not over them was demonstrated at the show by the Ford Company.

Many states now require that new cars be equipped with safety-glass windshields and practically all makers provide safety glass all around at a small additional cost.

While it is not intended to discuss the individual cars in general, this account of the show would not be complete without a reference to the "120" Packard car. This is largely because the entry into the medium-price field of a company, which, since its inception, has catered to the luxury class, is an important illustration of the trends of the time.

Since 1929 the depression has affected financial standing and spending ability not only of the average man but of the rich as well, with the result that a tendency has been to put more into the present-day automobile without raising the price to the extent where it would affect the purchasing of cars. As a result the really cheap car of, say, ten years ago has practically disappeared, the cheaper five-passenger sedans running to more than $700 when the actual selling price, rather than the meaningless f.o.b. factory price, is taken into consideration. The appearance under these conditions of a Packard car selling for slightly more than $1000 is significant, as it indicates that, for the time being at least, the market for highly luxurious cars is going to be a slim one and that the medium- and low-price ranges provide the greatest financial promise.

The superballoon tire is making some progress but not as much as was at one time expected. It does not appear that its adoption when made has materially affected the design of either the springing or the shock absorbers. On the other hand, there is no evidence that where superballoon tires have been adopted they have produced the wave of accidents which some engineers and users anticipated.

At the high speeds of operation of present engines the ordinary babbit bearing no longer stands up, and the tendency has been to use stronger materials. A number of companies have introduced copper-lead bearings and a few have gone to copper-silver alloys. Automobile and oil-refining company engineers are greatly interested in some of the features of the operation of the copper-lead bearings. The copper-silver bearings have not, as yet, been given sufficiently extensive test to determine completely their performance.

Ford now makes the cast crankshaft standard. Another interesting feature (e.g., Nash), the overdrive, permitting the car to run at high speeds without correspondingly speeding up the engine, is finding increased favor with several builders.

Practically all the cars at the show indicate that increased attention is being paid to water cooling. For example, the Plymouth engine has water jackets extending the full length of the cylinder bores. The Lafayette cooling system operates under sealed pressure controlled with a two-way valve built into the radiator filler cap. Holes of predetermined diameter are provided in the cylinder-head gasket. Pontiac uses a cross-flow type of radiator with thermostatic water-temperature control for short warm-up periods and cool-motor operation. Special means are provided for valve cooling.

The Continental Motor Co. has shown a radial Diesel engine intended for railroad and similar applications. It is claimed to give 635 hp for an engine weight of only 3900 lb. The engine is of the single-sleeve-valve type, providing two-cycle operation with uniflow scavenging. The overall diameter of the engine is 71 in. and the overall length 41 in. The same company exhibited carbureter-type engines burning fuel oil.—Leon Cammen.

Applications of Science to the MAKING *and* FINISHING *of* STEEL

By JOHN JOHNSTON

UNITED STATES STEEL CORPORATION

AS ONE who is by training and experience a physical chemist rather than a metallurgist, I may have a point of view somewhat different from that of those who are more directly concerned with metallurgical operations, a somewhat different philosophy of the broad question of the making of steels best fitted for the purpose which they are to serve. It is my aim to outline this general philosophy, rather than to discuss specific details, and to indicate my present views as to what systematic investigation can accomplish toward further improvement in control over the art of steel making, and toward providing in uniform quality that steel which is best fitted for each particular use, with reference, particularly, to the more and more exacting conditions which the engineer is asking steel to meet. It is a large subject to discuss in a short time; it is obvious, therefore, that many of its aspects must be omitted, and that only a few examples can be given of the kind of precise information requisite as a sound basis for further progress. These examples have been chosen as being somewhat less familiar to you who are, I presume, users rather than makers of steel.

Perhaps it would be well to begin by considering the debt which the art of steel making already owes to scientific investigation. In such an ancient art it is not easy to state this debt precisely, because, until recently, the scientific investigations which have in fact benefitted the steel industry have been carried on entirely outside that industry, largely indeed without thought of benefitting any industry. But there can be no question that without the aid of science the condition and magnitude of the steel industry would have been very different. For the great expansion of the steel industry since the beginning of the present century has been brought about largely by the growth of other industries, such as the electrical and automobile industries, which followed upon the application to them of science based ultimately upon the work of men such as Faraday and Clerk Maxwell. Conversely, these industries could not have developed as they have without the technological advances already realized in the making and finishing of steel on a large scale.

A familiar example is that without alloy steels there could be no high-speed tools, with the incalculable advantages which they brought with them; but these alloy steels could hardly have been developed until the alloying elements themselves had been discovered and their preparation and properties had been studied. Indeed, a century passed before much application had been made of this knowledge, most of the elements used in steel having been described before 1800; and in the proper application of alloying elements much more remains to be done than has yet been achieved. Again, the making of steel is now continuously controlled by repeated chemical analyses, by use of methods which were, in the first place, invented without reference to industrial use and developed over decades before any one thought of using them regularly to control the gross composition of steel. But these methods give us information only as to the relative amounts of the several constituents determined by them; they tell us nothing as to the way in which those constituents are combined with one another. In other words, they tell us the kinds and quantities of our primary building materials but nothing as to the architecture of the building. But just as the architecture of a building determines its usefulness, so does the architectural structure of a steel determine its practical usefulness; consequently, something more than analytical chemistry was needed.

Knowledge of the mode of combination in steel of the constituent elements has grown rapidly, especially during the last 20 years, with the systematic use of other methods of investigation—for instance, the microscope, the X-ray spectrograph, the dilatometer—combined with increasing attention to important factors such as the temperature, and duration, of the treatment of the metal. The proper interpretation of this information derives from an abstruse paper published nearly sixty years ago by Willard Gibbs, the greatest imaginative scientist yet produced by America, and one of the greatest of all scientists. Gibbs, however, was so far ahead of his time that many years elapsed before chemists discovered the profound significance of his work, which has in the last quarter century largely revolutionized the science of chemistry. With the application of Gibbs's thermodynamic principles in many laboratories, by many men, in many countries, it became possible to correlate, hence to control, many phenomena which previously had seemed to be separate and even mysterious; and many methods, based on this work, are now used every day in the steel industry, frequently with little appreciation of the difficult road traveled in perfecting the tools and methods of investigation and in learning to interpret the observations correctly.

This development was possible only by collateral development of other knowledge and other technical advances based upon research in pure science; for instance, methods of accurately measuring and controlling temperature, of securing suitable refractory furnace linings; the whole technique of the microscope, of the preparation of specimens for such examination, and of the identification by this means of the many different kinds of microscopic structure, helpful or harmful, which may occur. Indeed, a very interesting book could be written which would trace the development of the technical side of steel making back to the sources; but the ramifications into physical science would prove to be so many and various that the writing of such a book would be long and difficult.

I recount this to remind you that the steel industry has made considerably greater application of the results of scientific research than it is commonly given credit for; though it

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must be admitted that there was a large time lag between the discovery of this knowledge and its utilization, and that many possibilities had not even been considered. This, indeed, was true of nearly all industries until very recent years, when those most alert to improvements in their tools and processes discovered that they could lessen this time lag from years to months by having their own research group whose duty is to investigate *systematically* the possibilities of improvement in process and product by the utilization of new knowledge and the application of new scientific tools. This policy, properly carried out, proved so successful that there are now few major industries which have not adopted it in some form, so much so that it has by some been asserted to be a major cause of the depression from which we are now slowly emerging. The rapid technical development of other industries brought with it demands for better metals, for metals to meet new and far more exacting specifications, demands which at the time the art was unable to meet satisfactorily.

The enormous expansion of the steel industry in this country has come about as a direct result of the cheapening of steel made possible by mass production. This has involved wonderful development work, as exemplified in the building and operation of larger and larger furnaces, of larger units generally, the replacement of human labor by machines with corresponding greatly increased use of power, nevertheless, with a lessening of the total fuel used per ton of finished product. These achievements are impressive and of the highest importance economically; without them steel would have cost so much more that its use must have been far less extensive than it has been. For it is the amount not merely of the steel in your car, but of the steel in all of the large number of machines and factories taking part in the production of the finished car, which enable your car to be produced on such a large scale, hence so cheaply, as it is. These achievements in organization and production have gone so far that no further appreciable lessening of cost of ingots and billets can be looked for from further mechanization. Indeed, a large fraction of the present cost of semi-finished steel is for the raw materials delivered at the plant, a large, and in recent years increasing, fraction of this large item of cost being for transportation of those materials to the steel plant; and this part of the cost of steel seems likely to continue to rise more than can be compensated by any possible further improved efficiency in the use of the raw materials. The possibility of improving the economy of steel to the consumer is therefore largely a matter of improving its uniformity of quality, of fitting steels better for each of the multifarious uses, rather than of any direct lessening of its cost of production.

The steel produced has been, and is, entirely satisfactory for a great many of the purposes to which it is put; but with the rise of the automobile industry, a period which began approximately with the World War, there arose a continually increasing demand for steel of higher, and more uniform, quality at a low price. This insistent demand raises many problems, problems which are not likely to be solved except by thorough systematic investigation, in part of things which have been quite generally supposed to be definitely known and established on a firm basis of fact. These problems fall into two apparently rather distinct categories; yet they are so closely intertwined that they cannot in practice be separated:

(1) Development of further and more precise knowledge of the factors which determine the useful properties of a steel, as a means of selecting consciously that steel which is best fitted for any particular use; in other words, the manifold problems involved in finding out what should be made.

(2) Further improvement in control of the processes as a means of securing still better uniformity of any given kind of steel; in other words, the problems involved in actually making just what is really wanted.

These large questions obviously involve a study of the chemistry, if you will the physical chemistry and physics, of the processes of steel-making and of the steels produced in all the various ways. The solution of these manifold problems and the practical application of this knowledge require the use of tools and modes of control more sensitive and more reliable than the operator's unaided senses, no matter how skilled he may be. These tools and methods must be, and will be, invented and developed; they range from the accurate measurement and control of the highest temperatures to the provision of better refractories; from rapid methods of analysis for dominant factors in slags and in liquid steel to rapid tests of quality on the semi-finished steel; from simple chemistry and physics to recondite applications of electron behavior; from simple proportion to the use of modern statistical methods which enable one to use the steel plant as the laboratory.

Steel making is an ancient and wonderful art, developed through a long experience; perhaps because of this, it is far from easy to discover the precise facts underlying the processes used in the art. A question elicits varied responses which differ in emphasis and may even seem to be contradictory. For example, there is a wide difference of opinion among practical men on questions such as: In how far is the quality of a finished steel of fixed chemical specifications influenced by apparently small differences in raw materials, or in furnace practice, or in deoxidation practice? Should steel be poured "hot" or "cold?" What kind, size, and shape of mold should be used? What is the best rolling practice? and so on. Indeed, one may venture the remark that no two steel makers produce the same steel in *precisely* the same way, just as no two artists produce the same effect in precisely the same way. Yet it is far from certain that a combination of what might seem to be the best features of all the present methods and artifices would yield even as good a product as the skilled operator now makes.

Altogether, then, there had been, until recent years, but little systematic thorough investigation of many of the really fundamental problems involved in the proper making and use of steels; and many of the studies which had been made had led only to somewhat indefinite, even ambiguous, conclusions. This pointed to the necessity of making rather fundamental investigations, to secure a firm basis upon which one could, with confidence, start building, without being too much concerned with achieving immediate improvements in manufacturing practice. But what may one take as reliably known? The metallurgical books seem to assume that all is known, and generally state the matter in simpler terms than correspond to the facts. The chemical books give, with respect to the element iron, its reactions, and compounds, so little concordant information that they are not very helpful. One is therefore constrained to rely largely on one's judgment and general experience in deciding where and how to start, and as to what may safely be accepted as a firm foundation on which to build and what is still doubtful or unknown.

We were, however, convinced that certain principles—which may be designated as the principles of physical chemistry—would be found to apply to this more complex case just as they are known by experience to apply to simpler chemical cases, if we had the wit to make the appropriate measurements and to apply these principles properly. In other words, the seeming anomalies and mysteries result from the complexity of the system, from the large number of variable factors, and not from the intervention of some new and strange principle. And we are now entirely persuaded that this is so.

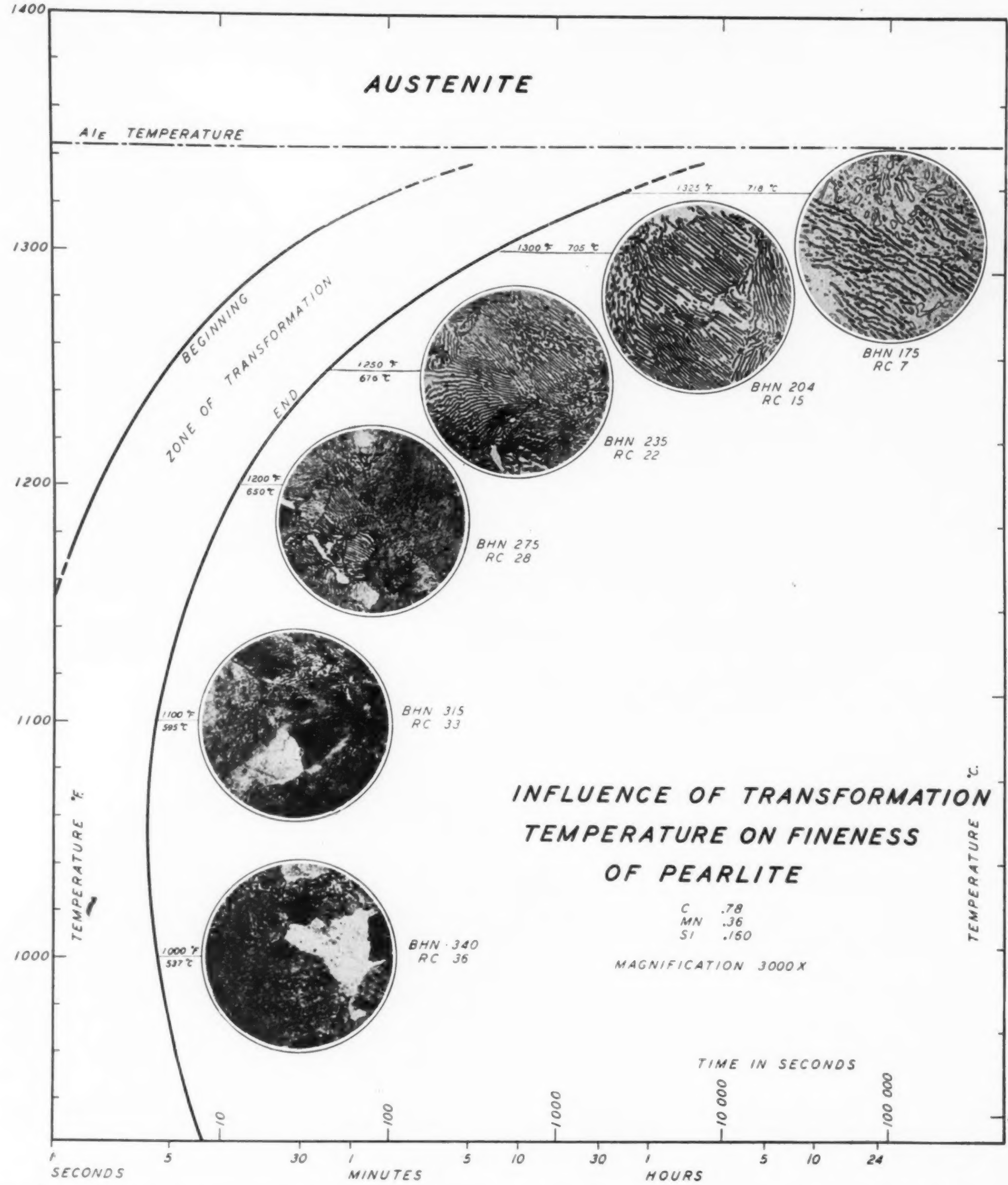

FIG. 1 INFLUENCE OF TEMPERATURE AT WHICH THE CRYSTAL TRANSFORMATION IS MADE TO PROCEED TO COMPLETION UPON THE STRUCTURE AND PROPERTIES OF A STEEL CONTAINING 0.78 PER CENT CARBON, 0.36 PER CENT MANGANESE, 0.16 PER CENT SILICON

A second general guiding principle, which so far has not failed us, is that the physical and mechanical properties of any ordinary or low-alloy steel—say, any steel containing more than 95 per cent of the element iron—depend upon the final intimate architecture of the metal, and not upon the precise way in which this detailed structure came about. A particular structure may happen to have been built up by some special deoxidation practice, by an alloy addition, by a mode of working, by a specific heat treatment, or by some combination of these (or other) factors; we have therefore to discover which combination of the possible methods yields most easily, that is, at the lowest overall cost, the properties desired in the finished product.

Consideration of this matter brings us back directly to a very

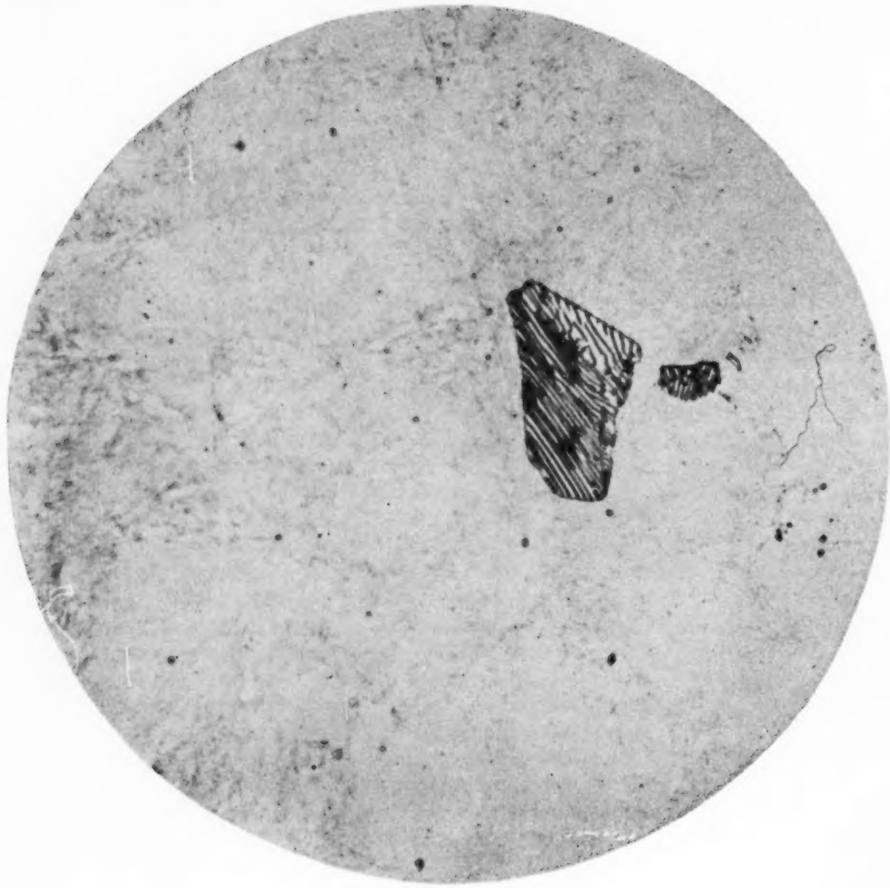

Fig. 2

Fig.

FIGS. 2–6 RATE OF TRANSFORMATION OF A EUTECTOID CARBON STEEL (0.85 PER CENT CARBON) AT CONSTANT TEMPERATURE (1300 F)

(Identical specimens heated to 1625 F were transferred quickly to a lead bath at 1300 F, left there for the interval stated opposite, then quenched into brine; the white ground-mass was austenite at 1300 F, but was, by the brine quench, converted to martensite (supersaturated solution of carbon in α-iron) and appears as such in the photomicrograph. Magnification 1000 diameters.)

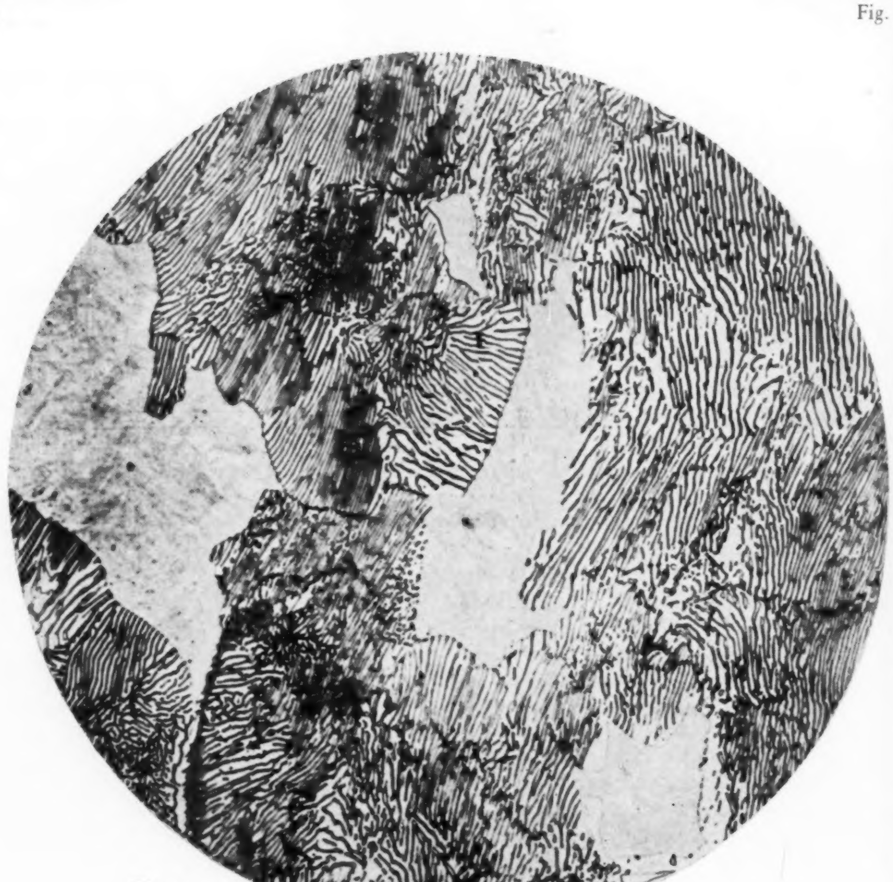

Fig. 5

Fig. 3

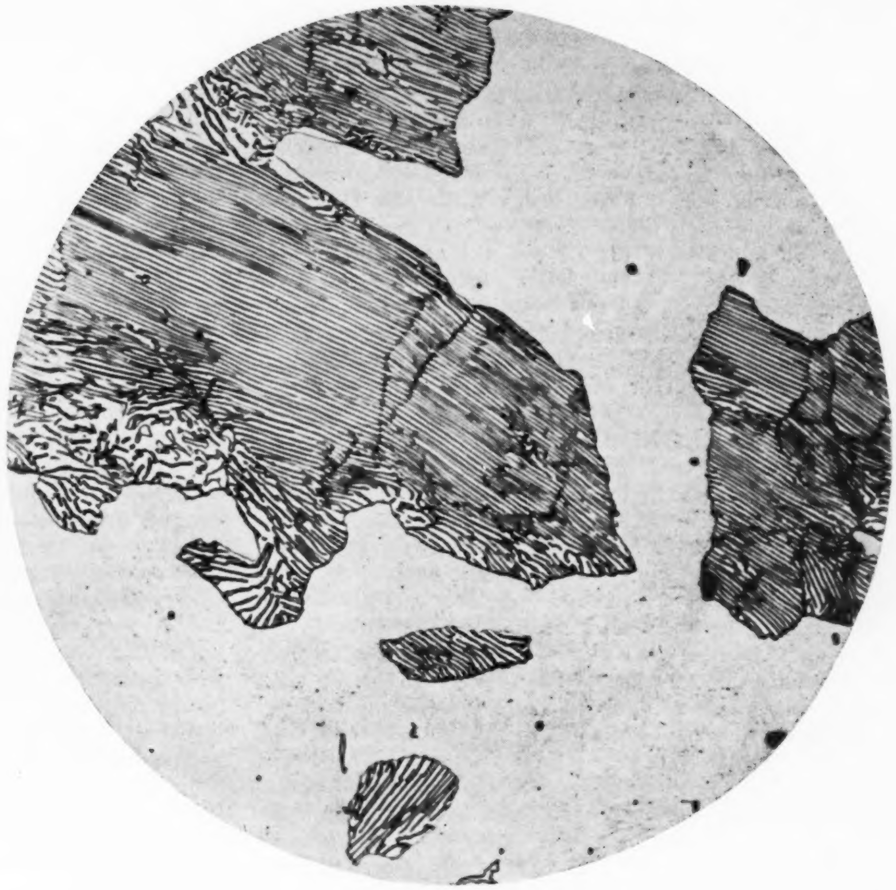

Fig. 4

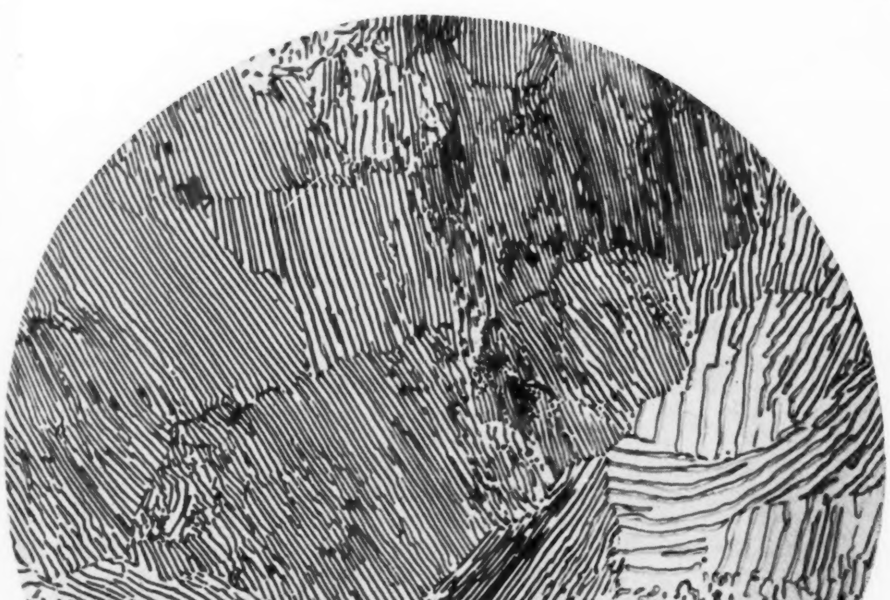

Fig. 6

THE TIME INTERVALS DURING WHICH CERTAIN STAGES OF THE TRANSFORMATION TOOK PLACE WERE AS FOLLOWS

	Time interval at 1300 F, minutes	Transformation
Fig. 2	6	Just beginning
Fig. 3	19	About $^1/_4$ completed
Fig. 4	22	About $^1/_2$ completed
Fig. 5	24	About $^3/_4$ completed
Fig. 6	60	Complete

fundamental question, Wherein precisely does iron (or steel, if you will) differ from the other common metals? To what peculiarity of the element iron, apart from its abundance and cheapness, is due its supreme position as the most useful metal? There is, in my mind, no doubt as to the answer: Of the common metals iron is the only one (except for tin, which is so different that it need not concern us here) which occurs in two distinct crystalline forms, and it so happens that these two forms have a very different solvent power for other atoms, for carbon atoms especially. From this arises directly the possibility of producing very different results by varying the mode of heat treatment of steel; otherwise, many things now commonly done would be impossible, or at least impracticable on anything like the present scale. For the success of all of these heat treatments depends ultimately on the facts that carbon is much less soluble in α-iron (ferrite, the form stable at low temperatures) than in γ-iron (austenite, the high-temperature form), and that the mode in which the carbon appears in the finished steel depends upon the way in which we cause it to precipitate, upon the way, therefore, in which we cause the crystals of γ-iron to transform to α-iron. Moreover, the wide variation possible in the temperature range within which the crystals transform depends upon the circumstance that in steels the transformation $\gamma \rightarrow \alpha$ proceeds at a relatively slow rate; and this slow rate (which is far from universal in transformations of this type) enables us to make the carbon precipitate at any temperature within a wide range.

Incidentally, it may be mentioned that within recent years a number of strong alloys, notably of aluminum, have been developed, which are based upon a precipitation of another element (or compound) brought about by the change with temperature of its solubility in a single crystalline form of the principal metal. The proper use of this general method of increasing strength and hardness of a metal demands a degree of refinement in control of the operations which has become feasible only within recent years, whereas the hardening and tempering of steel have been practiced successfully for centuries.

To return now to the crystal transformation of iron in steel in the so-called critical-temperature range, a somewhat misleading term which I would like to see go out of use. A steel when heated begins to transform at a temperature very near to the real initial equilibrium temperature, no matter what the rate of heating, and the transformation is complete before the temperature of the steel actually transforming has risen more than a few degrees above the final equilibrium temperature. When cooled, however, it does not transform in the equilibrium-temperature range unless it is cooling very slowly. The more rapid the cooling, the lower is the actual transformation temperature; with very rapid cooling, as in quenching, the steel behaves differently, the resultant product being analogous to (and possibly, identical with) a supersaturated solution, or better, to a glass which on subsequent reheating (tempering) partially or completely devitrifies—that is, transforms to a more stable state in accordance with the inherent rate of reaction at the temperature.

At every actual temperature of transformation there is, *for a given steel*, a definite speed of transformation, and correspondingly, a definite final structure; and both the speed and the resultant structure change very markedly with change in the temperature at which the transformation actually occurs. At temperatures just below the equilibrium transformation temperature (that is, the A_e point) the product of transformation is a coarse pearlite, a banded, or lamellar, structure; at lower temperatures, the pearlite produced is finer and finer, and finally so fine that it is unresolvable under the microscope. This is most directly shown by causing small pieces of the steel to transform in a metal bath, held at one of a series of constant temperatures; but it can also be brought about by varying the rate of cooling prior to the onset of the transformation. This general phenomenon is entirely analogous to many well-known examples of precipitation and crystallization of barium sulphate, for instance, which can be produced in crystals ranging in size from several millimeters to submicroscopic, and even ultramicroscopic, merely by changing the degree of virtual supersaturation of the solution within which it is precipitated.

Alloying elements alter the transformation temperature, in some cases lowering it, in others raising it; more significantly, they slow it up, in some cases tremendously. Thus a given cooling rate results in a lower actual transformation temperature, and in the structure corresponding to this lower temperature of precipitation of the carbide; that is, it results in a finer pearlite and consequently in a harder and stronger steel. This we believe to be the outstanding effect of an alloying element, though, of course, some of them are, or are also, chemical reagents in the finishing stages of the steel-making process, and by so reacting modify the *real* composition of the steel.

I stress *real* composition, because what has been accepted as the composition of a steel—its so-called chemistry, as determined by the classical methods of analytical chemistry—does not in itself tell the whole story of the behavior to be expected from the steel. For its actual behavior is determined not only by the proportions of the elements usually analyzed for, and of the alloying elements added intentionally, but also by the presence of very small proportions of elements such as oxygen, nitrogen, and possibly hydrogen; and in these cases especially it is less a matter of the proportion than of the mode of combination in which the element is present and its mode of distribution in the metal. For instance, the influence of a small proportion, say 0.01 per cent, of oxygen, is very different according as it is present wholly in the form of mineral particles, such as alumina or silicate inclusions, or in solid solution in the crystals of the metal itself. This leads me to state our present belief that in general the useful properties of a steel are affected much less by the mineral particles visible under the microscope—the so-called non-metallic inclusions—than by those which with present technique cannot be seen at all. This is another example of the large effect which may be produced by the presence of a very small percentage of the proper material, properly distributed; as an analogy we may think of a masonry structure, the strength of which depends on what was used as cement and how it was laid on, even though the total weight of the cement is but a very small fraction of the total weight of the structure.

The circumstance that two steels of identical nominal composition may differ markedly in their response to certain treatments—a circumstance which has been generally admitted only within the last two or three years—suggests that many of the specifications for steels lay stress on some things which are of far less significance to the user than other points which are not even mentioned in the specifications. Undue emphasis has been laid on the ordinary chemical specifications; and this has brought about the situation that the steel maker has to make steel to five, or even ten, times as many different chemical analyses as are really necessary. This excessive number of chemical specifications implies that the user not only ultimately pays somewhat more for his steel but also that in general he gets a metal of less uniform quality than he would get by buying a steel which the steel mill could make in a large number of successive heats. After all, the user is not really concerned with the gross chemical composition of the steel; what does concern him is its intimate structure, no

matter how it may have been secured, and how it fulfils his purpose. In specifications I should like to see relatively more emphasis put on this aspect of the matter and less on the ordinary chemical analysis.

A kindred point is that, in our opinion, undue stress is laid in specifications upon the difference between bessemer steel and open-hearth steel. It is true that there are differences between them, as usually made; that bessemer steel is more suitable for some purposes, open-hearth steel better fitted for others. But these differences must be attributed to differences in real composition, for it is to me inconceivable that steels of *completely identical* real composition should not have completely identical properties, no matter from what materials or by what process they were made. Indeed, the actual result depends upon the conditions under which the process was carried out, particularly in the finishing stages, perhaps more than upon the type of process in itself. For the reactions are essentially identical in both processes; in the bessemer we oxidize directly by blowing atmospheric oxygen through the liquid metal, whereas in the open-hearth furnace we oxidize the liquid metal by means of the iron oxide in the slag in contact with it. Thus the two processes differ only in the means by which the reactions are brought about, and in practice to some extent because in general they are used to make different types of steel. Similar remarks apply to steels made in the electric furnace, which are not necessarily superior merely because they were made in an electric furnace.

The character of a steel of a given chemical analysis is influenced by the way in which it is finished, in particular by the real composition of the liquid steel and of the slag then in contact with it, and by the mode of "deoxidation." It is not yet certain whether this so-called deoxidation is merely a partial or complete precipitation of oxygen from the steel, or involves other simultaneous reactions, as with nitrogen or sulphur. But oxygen appears to be the dominant factor, though just what happens may be influenced by the presence of these other non-metallic elements. Nor do we want an absolutely pure steel, for such steel would be largely useless for most purposes because it would be coarse-grained and remain so in spite of repeated heat-treatments. What is wanted is a steel with just the right amount and kind of non-metallic matter, properly distributed through the steel; I was going to say dirt, but dirt is defined as matter in the wrong place, whereas here we want matter in the right place. You can see that all of this makes it difficult to reach a definitive solution of this whole question; but very satisfactory progress in this direction is being made now when the real question is being faced by the steel maker, who is going to furnish to the engineer the steel in uniform quality which will best meet his more and more exacting requirements as he proceeds to employ higher and higher unit stresses, higher temperatures and pressures, and so forth.

You are not to infer that this difficulty of securing uniformly the best real composition of the liquid steel is the sole obstacle in the way of producing steel of absolutely uniform highest quality, for perfectly good liquid steel in the ladle may be spoiled by improper subsequent treatment—by improper pouring, heating, rolling, or finishing. But it is true that a steel which in the ingot was not right for a particular use, cannot, in general, be made right by subsequent juggling.

From these remarks it will, I think, be clear to you that, whereas to make a steel within close limits with respect to the ordinary chemical analysis is relatively easy, to make a steel of absolutely uniform high quality, heat after heat, is far from an easy matter, involving as it does some very elusive factors. Moreover, some of the factors encountered in prac-

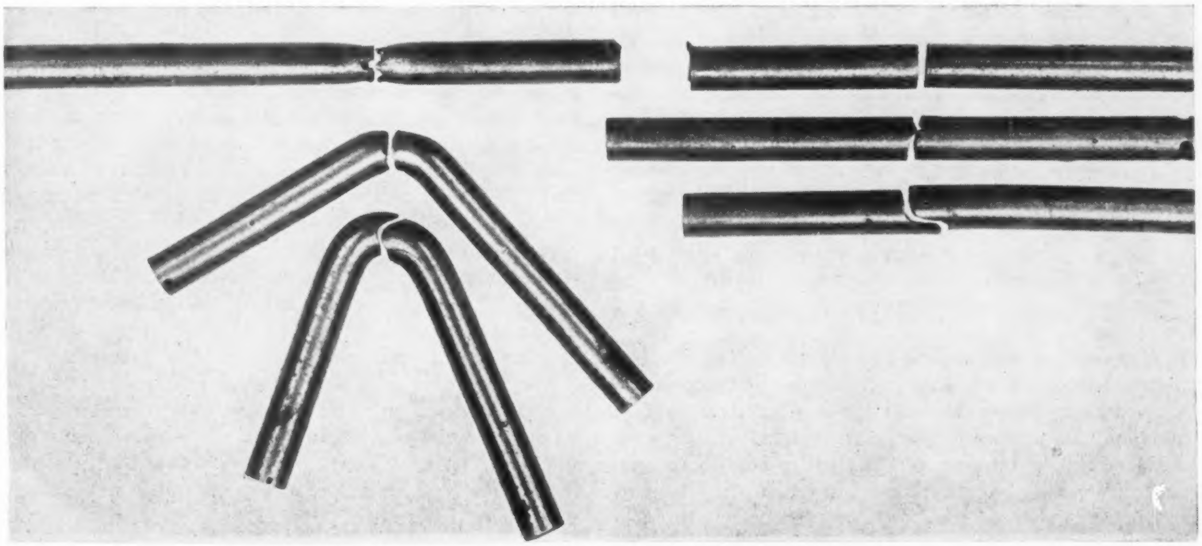

FIG. 7 COMPARISON OF SOME MECHANICAL PROPERTIES OF INITIALLY IDENTICAL SPECIMENS OF A STEEL (CONTAINING 0.74 PER CENT CARBON, 0.37 PER CENT MANGANESE, 0.14 PER CENT SILICON) PREPARED BY HEATING THE SPECIMENS TO 1450 F, WHICH WERE THEN EITHER:

A (LEFT) QUENCHED IN LEAD-ALLOY BATH AT 580 F AND HELD THERE FOR 15 MINUTES TO COMPLETE THE TRANSFORMATION PROCESS, OR

B (RIGHT) QUENCHED IN OIL AT 70 F AND TEMPERED IN A LEAD-ALLOY BATH AT 600 F FOR 30 MINUTES

TOP PAIR, AFTER TENSILE TEST; MIDDLE PAIR, AFTER IMPACT TEST; BOTTOM PAIR, AFTER SLOW-BEND TEST

	A Direct transformation at 580 F	*B* Quench and temper
Hardness, Rockwell C	50	50
Tensile strength, lb per sq in	283000	247000
Elongation in 6 in., per cent	1.9	0.3
Reduction in area, per cent	34.5	0.7
Impact, ft-lb	35.3	2.9

tise are opposed in effect, and therefore there must be some sort of compromise between them. For instance, to minimize the phosphorus content necessitates a temporarily high oxygen content which must somehow be removed later. Indeed, I am tempted to wonder if the presumed adverse influence of phosphorus is not in part because the steel quality may have been spoiled in endeavoring to bring the phosphorus content down beyond where it is actually necessary to bring it. For we are persuaded that phosphorus, within reasonable limits, is a hardening element in all respects analogous to carbon, and should be taken into account in comparing the properties of different steels. Indeed, a statistical comparison of a very large number of steels shows that the hardening or strengthening influence of one point of phosphorus is equivalent to that of about 3.5 points of carbon. On this basis a steel with 0.08 carbon and 0.02 phosphorus is equivalent to a steel carrying 0.15 carbon with a negligible percentage of phosphorus. When compared on this basis, some of the differences between ordinary bessemer steel and open-hearth steel disappear.

Incidentally, it is a fortunate circumstance that at ordinary steel-making temperatures most of the elements we wish to remove oxidize more rapidly than does iron. But these relative rates can be changed, for instance, by change of temperature; for example, chromium usually oxidizes out ahead of carbon, but there is good evidence indicating that at higher temperature the relative rates reverse and that then carbon will be removed by oxidation ahead of chromium. But to do this in practice involves improvement in refractories, which is a large and difficult question in itself; the difficulty is perhaps less in getting something to stand the high temperature than in finding something which will withstand the solvent action of the iron oxide in the slag and the apparently unavoidable rapid temperature changes. In fact, there is no steel-making problem which does not immediately branch out into a great number of problems, so many, so diverse, in part so difficult experimentally, that they will not be solved satisfactorily all at once or for a long time to come. What has been accomplished recently is bringing about almost a revolution in the methods of making quality steel and in our knowledge of its intimate architecture; for instance, as to just how seemingly slight variations in the make-up of the metal may bring about significant differences in this architecture, hence in the useful properties of the steel. Incidentally, it seems to us more logical to draw a distinction not between alloy steels and plain carbon steels as is usually done, but between quality steels—which may or may not contain special alloying elements—and ordinary steels.

There is an important implication of the fact that the quality of the finished steel is determined not alone by its composition deduced from the ordinary chemical analysis, but also—and in some cases, more significantly—by other factors, such as grain size which affects the response of the steel to heat-treatment, and the precise mode of heat-treatment to which the steel had in fact been subjected, whether by intention or not. It has been usual to attribute differences in the measured mechanical properties of steels to differences in given composition, as determined by ordinary analysis, as if this were the only significant variable; with the consequence that there are great variations in the value of any of the mechanical properties assigned by different authors to steel of any given nominal composition. As a further consequence, there is still considerable uncertainty as to the precise influence of a variation in the relative proportion of the several elements, whether added intentionally to make so-called alloy steels or not, upon any of the mechanical properties of steel; and this difference of opinion is doubtless the main source of the excessive number of separate chemical specifications which the steel maker is called upon to meet. The clarification of this whole matter now in progress will, in time, put the engineer in possession of more precise and more reliable data on the properties of the quality steels available for his use; and this, with the greater uniformity of the steel, will enable him to design more precisely, with a still smaller so-called factor of safety and a further lessening of deadweight of his structure or equipment.

In conclusion I wish to refer briefly to the degree of significance of mechanical tests and to suggest that the mechanical engineer look more closely at them, preferably, perhaps, in collaboration with a metallurgist familiar with the previous history of the specimens tested. For it looks as if some of these mechanical tests, as now carried out, may not have the significance commonly ascribed to them, except as purely conventional engineering comparisons. The usual interpretation of the results implies tacitly that the material was strictly homogeneous and initially stress-free, and that its architecture remained essentially unaltered by the deformation imposed by the test; but no one of these assumptions is rigorously true. This matters little so long as a large factor of safety was included in the computations, but must be kept in mind as the metal is used under more and more exacting conditions. Moreover, all of these tests measure some mixture of cohesive strength and resistance to slip, but not in the same proportion for different metals, or even for the same metal at different temperatures of test. Even the so-called elastic limit is observed at lower and lower stress as the sensitivity of the means of observation is increased. It would seem to me preferable, therefore, to express the results of these mechanical tests in terms of the stress required to produce one or more specified amounts of permanent deformation—that is, directly in terms of the quantities observed and required in design—rather than as some kind of modulus which would be valid only if the stress-strain curve were strictly linear over the whole range of stresses considered.

In this connection I would like to remind you that in all cases a service test is the final criterion, and that the results of no approximate or indirect test can be safely accepted as a reliable prediction of what will happen in service until they have been definitely correlated with the results of actual service tests. This is especially true of all accelerated tests of resistance to corrosion of one kind or another, or even of resistance to fatigue or to creep at high temperature; for in the very acceleration of the process we introduce a change in the intensity of some factor which may change some essential condition and so cause the test to be misleading as an indication of what will happen in service over a long period.

The foregoing is a very general reconnaissance of a large region of which only the outstanding features are yet known; its detailed mapping will require the work of many explorers and frontiersmen. I have tried to indicate that whereas much remains to be done before steel production is thoroughly on a scientific basis, much has been accomplished toward the ideal of controlling the processes so that they yield a uniform product with the best combination of qualities desired for any specific purpose. A good deal of the necessary fundamental information is still lacking, but this lack is now more generally appreciated, and the information will be forthcoming. The old experimental tools and technique have not all been used to their limits; new ones will be developed. The requisite investigations are not easy, but are so interesting and will yield such valuable results to the industry, that they will attract a larger number of men; so that progress in real knowledge of the properties and capabilities of steels is going to be more rapid than ever before.

ENGINEERS' BUSINESS CONTACTS

Introductory Address of a Series Being Delivered at the Engineers Club of Baltimore

By A. G. CHRISTIE

THE JOHNS HOPKINS UNIVERSITY, BALTIMORE, MD.

I HAVE the honor tonight of delivering to the younger engineers of Baltimore the first of a series of addresses on "Business Fundamentals in Engineering." You will be interested to know something of the idea back of these talks and the purpose for which they are offered.

The average engineering graduate leaves his Alma Mater with, what seems to him, a vast and profound knowledge of science and its applications, and with the idea that if the world will but give him his chance, he will outshine Edison, Steinmetz, Diesel, and others, as a great inventor and engineer. These are laudable ambitions but they lead many a graduate to develop a false sense of his place in the business world. In normal times, college graduates take various minor positions in industry, appreciating the fact that they have to become familiar with certain processes before their real engineering starts. However, after a few years of such experience, their expectations of rapid technical advancement have failed to develop, nor does there appear to be any possibility of this development in the immediate future. This leads to disillusionment and discouragement. Many men become hopelessly adrift after about three years out of college and it takes more than usual courage and back-bone for them to buck up and face the real facts. Those who allow themselves to drift, generally become the misfits in the engineering profession until their attitude changes.

WHAT CONDITIONS CONFRONT GRADUATES?

Let us see what are the actual conditions confronting such engineering graduates. Statistics show that 70 per cent or more of engineering graduates finally reach supervisory rather than strictly technical positions. Their jobs require the execution of tasks that are largely of a business nature. Many have had little or no formal training in business principles or methods, and their earlier progress has been due to personal characteristics and to knowledge acquired in industry. Their engineering training has in many cases enabled them to accomplish their tasks more directly than otherwise, but much of this technical learning has little direct application to their jobs.

Since a greater portion of you will arrive in such supervisory positions ranging from executive officials down, the Directors of the Engineers Club of Baltimore decided to offer this course of lectures on "Business Fundamentals in Engineering." Its purpose is to inspire you to give greater consideration to business in your professional life and to direct your attention to the social, economic, human, and commercial relations that influence modern industry. The object of these lectures is, therefore, to arouse interest in the business elements that exist in the work of those who hold staff positions in industry, and thereby to increase your value to yourself, to industry, and to the nation. In other words, let our aim be to introduce more business in engineering while you are putting more engineering in business.

There never was a time when there was a greater need for a thorough knowledge of business than the present time. There never were greater opportunities for success than are presented by the difficult and complicated conditions at present confronting business. The leaders of business in the next few years will be those, at present, unheard-of men who forge ahead owing to their greater ability to analyze successfully the new problems confronting them.

WHAT ARE THE BUSINESS CONTACTS OF ENGINEERS?

What are the business contacts of engineers? These contacts are with their associates and superiors in industry, with those with whom their employers have business connections, and with such others as one has to deal in normal life, such as property owners, bankers, storekeepers, and government officials. Business contacts are greatly influenced by one's personality.

The remainder of this address will be devoted to a consideration of certain personal attributes that have a dominating effect upon one's business relations.

The trying experiences of the last few years have done much to lessen the rugged individualism of the average American. Ralph E. Flanders in a recent address said:

> The paralysis of courage and of individual responsibility has already touched the younger generation. From the natural feeling of helplessness in the face of the recent economic crisis, there first developed among the youth a shame-faced acceptance of public support, which, in far too many cases, has ripened into complete dependence upon society. From this, it is a short and easy step to direct demand of support as a right without compensatory duties.

A recent report covering education in the social sciences is permeated with the idea that in the future one must prepare for a collectivism, and an economy marked by integration and interdependence. In other words, it is alleged that individual initiative will be largely replaced by bureaucratic government control.

HUMAN NATURE WILL REMAIN THE SAME

I am not prepared to accept this view as I cannot believe that the American people will ever consent for any long period of time to such a regimentation. Those who prophesied in 1928 that the old laws of economics no longer held and that we were then entering a new era of high wages and plenty for all, were quite wrong. Those who see only government control and collective effort as a relief for our present difficulties, are, in my opinion, equally wrong. Human nature will remain the same. Individual initiative led to the great achievements of the old order, and similar opportunities exist for further developments in the future. Can any such advances be claimed for the New Deal as the finest telephone system on earth, our marvelous developments in automobiles, leadership in aviation, the best farm machinery produced anywhere, and many other achievements under the old order? These results of indi-

vidual initiative cannot be dismissed lightly in favor of untried regimentation.

Leadership—the result of personal initiative—will be as greatly needed in the future as in the past. Should rugged individualism not survive, leaders such as Stalin, Hitler, and Mussolini are necessary under the collective or dictatorial systems and these achieve leadership only from personal ambition and individual initiative. My advice to young engineers is to avoid government sinecure jobs and to become leaders in the business of this country.

CHARACTERISTICS EMPLOYERS HOPE TO FIND

What do employers expect of a college graduate? First and foremost is character. Sterling honesty, reliability, and the determination to work wholly in the interests of an employer should characterize every engineer. Next comes thoroughness in all details of the work which is assigned to him. Initiative is desired so that the young man does his work efficiently with a minimum of direction. Energy and will-to-work are valuable attributes, as well as tenacity in finishing a job. Technical knowledge and manual skill as a rule receive minor consideration when a new man is selected for a position in an industrial concern.

Have you developed these desirable characteristics to the fullest in your business contacts? Honesty of act and purpose must characterize all your activities. Don't try to take advantage of your employer by killing time on a job or by frittering away your efforts over trifles. These don't pay and sooner or later will react to your disadvantage. Equally important is the constant exhibit of a spirit of fairness and honesty in your commercial relations with others both in your own and in your employer's interests. No engineer of any standing would consider the acceptance of commissions on orders placed for a client or employer. A person who regularly tries to beat down the offerer's prices and to get special discounts, is soon caught by his own game. Sellers always boost prices to these men and appear to make concessions, but in the end the price often exceeds the standard price. The square deal is the best deal in the end.

Are you truly loyal to your employer's interests? Do you try to advance these on every opportunity? Do you have a fighting spirit for the reputation of "our company" and "our products?" The merging of your employer's interests into your own is one of the surest signs of real progress in business life. This singleness of purpose accounts for the success of many a practical man who rises from the ranks. He lacks the wide knowledge and training that you possess, but he has learned how to do a particular job well and his whole energy and attention is centered on getting his particular task done. He is not distracted by influences or factors of which, with his limited training, he knows nothing. Cultivate this habit of concentration and singleness of purpose in business.

Too many men lack a sense of responsibility for getting jobs and especially for holding them. They want only short hours and no night work. Yet any one entering engineering must recognize that, if he aims to hold any responsible position, his day is not over when he leaves the plant. He must study in his evenings those branches of knowledge associated with his work, business as well as technical. His early years in industry are, in fact, periods of preparation for his greatest productive work in later life.

BUSINESS IS BASED ON TEAM-WORK

A modern business is based largely on the team-work of its employees. Each strives to do his share so that the coordinated efforts lead to profitable accomplishment of the object desired, whether a bridge design, the manufacture of a lawn mower, or the supply of bulk electricity. Your contacts with your associates must contribute to this objective of profitable business success. Team-work requires a readiness to work overtime when necessary and to sacrifice personal desires when work must be rushed, or unexpected obstacles must be overcome. In athletics, team-work requires every one to strive whole-heartedly for the good of the team and this is achieved by exerting every effort to make a success of the individual plays of all other members of the team. Its members are so trained that the team-work will continue under a new leader should the captain leave the game. Team-work requires a study of the jobs of those with whom you are in contact and also of the job next above. When occasion arises, you will then know how to direct the work of others as well as to carry out your own particular part. One who makes a large contribution in placing his firm among the leaders will be richly rewarded with increased income and enhanced reputation.

Some of the most distressing statements one can hear are: "I'm only a cog in the wheel," or "I only get routine work." What future can such persons expect? They do not see beyond the mechanical side of their jobs. Most of the world's work is routine. The dentist fills tooth after tooth in the same old way. The college professor reads the same fool answers to the same questions year after year. What can be more routine than the work of a vice-president of a company who must countersign hundreds of checks a day issued in the course of the company's business? Too many college graduates forget that the greater portion of all supervisory and executive jobs consists of routine matters. Success lies in doing the routine work thoroughly, accurately, and speedily, so that time is available to study associated work and particularly to analyze the next job ahead. Be a dynamic member of your team, not a lifeless cog in a machine which may rapidly wear out from inattention.

The essence of team-work is helpful business contacts with fellow-workers. Its success is enhanced by certain personal attributes. Cheerfulness enables a man to work better, to be clearly understood, and to add weight to his opinions. No one likes a grouch and his opinions usually only rouse resentment and opposition. Sarcasm has little place in business affairs. Willingness to lend a hand to an associate in difficulty wins many a man a staunch and helpful friend. Faultfinding and complaining of the work of others should be avoided at all costs. If you have a real reason for objecting to the work of others, explain the matter in an impersonal way based on facts only, but be sure you have all the facts before you act.

VALUE OF A WIDE CIRCLE OF FRIENDS

One of the most valuable assets of any business or professional man is a wide circle of true friends. These can aid one in many ways: in promoting one's business, in assisting one with helpful advice and information, and in helping one when trouble threatens. Make every effort to expand your acquaintance particularly among those who are leaders in business and the professions. Many a man is looking for a capable assistant and he will generally choose this new man from among those he knows well. Make friends, true friends, at every opportunity.

Many men fail of their fullest success owing to a lack of consideration for the ideas and feelings of others. An incautious remark derogatory to a certain nationality or religion, may create enmity that can never be wholly removed. The lack of tact is often evident in engineers blessed with a brilliant mind. When an associate or subordinate broaches a new idea, this type of engineer will readily grasp its significance and will con-

ceive and state the result before the plan has been fully explained. Such action is disconcerting to the originator of the idea and makes him feel that he will not receive full credit for the improvement. He will be reluctant to present any further suggestions. Tact would dictate that he be allowed to develop his own idea and to demonstrate his results. His satisfaction in finding that you are convinced by his arguments tends to encourage further creative efforts. Many a brilliant career has been clouded by lack of tact in dealing with others.

CLEARNESS OF THOUGHT ESSENTIAL

Clearness of thought is an essential often lacking in one's business contacts. Many persons permit their minds to be confused by a wealth of half-considered ideas. Others allow their ideas to be readily modified by the arguments of the last person with whom they come in contact. Here again concentration will enable one to distinguish between essentials and non-essentials and to discard unnecessary and irrelevant considerations. This leads to directness, speed, and efficiency in business matters.

Every young man sooner or later experiences a situation in which he cannot see his way clear through to the end of the job. He is timid about undertaking the work. He should use his wits and get started. Walter Kerr advises young men in such circumstances to "go as far as you can, and then see how far you can go."

Ability to overcome the difficult tasks adds zest to life and develops that self-confidence which is a mark of leadership. A favorite character of mine is Kipling's Sir Anthony Gloster, the old shipbuilder, who on his death bed tells the story of his life in part as follows:

I knew—*I knew* what was coming, when we bid on the Byfleet's keel,
They piddled and piffled with iron: I'd given my orders for steel,
Steel and the first expansions. It paid. I tell you it paid.
When we came with our nine knot freighters and collared the long-run trade,
And they asked me how I did it and I gave them the Scripture Text.
"You keep your light so shining, a little ahead of the next!"
They copied all they could follow but they couldn't copy my mind.
And I left them sweating and stealing, a year and a half behind.

There was a natural-born leader, a two-fisted he-man and one whose success was the result of confidence in his own ideas and ability! We need more of these rugged individualists to tear us out of our present state of waiting for the government to do something.

One sometimes hears a young engineer say, "I'm doing as much work as the company pays me for." That man should be told that as far as business acumen is concerned, he is a perfect imbecile. Any one acquainted with the principles of industrial organization will recall that costs consist of direct labor, direct material, and burden or overhead. The burden may be equal to or even many times the cost of direct labor. Labor must not only earn its wages but must carry this burden as well. Any engineer who only does work equivalent to his pay is not earning the share of this overhead that logically falls to his job. He should render service to his employer of much greater value than his wages, if the business is to survive and to continue profitable. The greater the share of overhead that he carries, the more valuable he is to the business and the better are his chances for promotion.

Another commercial term that should apply to engineers is that used in central-station work—"readiness-to-serve." It implies the maintenance of good health and robust physique which fit a man to take up, willingly and instantly, any task of emergency or other nature that may fall to his lot.

Sometimes in spite of our best efforts, untoward circumstances intervene and we feel that all our work has come to naught. But if this work were well and honestly done, we may console ourselves with the words of the cowboy: "Life ain't in holding a good hand, but in playing a poor hand well."

OUTSIDE BUSINESS CONTACTS OF ENGINEERS

Just a few thoughts on the outside business contacts of engineers. What do you know about banking? How would you go about raising a bank loan for a legitimate business purpose? What are banking customs in regard to commercial paper? What would you do with a "Bill of Exchange?"

Or again, suppose you and your associates undertake a commercial enterprise, for instance, as contractors. What account books would you open? How would you keep these properly to fill out your income tax returns or your corporation reports to the state? What is your balance sheet? How would you analyze the balance sheet of another? How would you care for depreciation in making up a profit-and-loss statement?

Suppose that a party with whom you contract, fails to carry out his agreement, what redress have you? Or how can you legally terminate this agreement? What is the true nature of your contract for employment? How can you transfer real estate?

These and many other common commercial relations coming under the general headings of banking, accounting, and commercial law should be known to every person in engineering and in business. The engineer may study these privately or may take available evening courses in these subjects.

SUCCESS IN ENGINEERING IMPLIES A LARGE MEASURE OF SKILL IN BUSINESS

I have endeavored to point out in the preceding paragraphs, certain of the personal characteristics of an individual which influence his business contacts. Naturally many things have been left unsaid to be taken up more fully in other addresses of this series. Business offers many problems to the engineer for solution. The business depression was not the result of a failure of engineers to manufacture goods, but of an economic congestion in their distribution and use. The problems of distribution in business will tax the best ability of any engineer who undertakes their solution.

Since an engineer's daily life consists of such business contacts, it behooves him to develop these relationships for his employer's and his own advantage. The analytical training of the engineer will aid him to understand readily and apply intelligently the principles of business. He must realize that the jobs to be done depend quite as much on business factors and influences as upon mathematical calculations and scientific research.

Engineering success implies a large measure of business skill. Success in any field comes only from the employment of the best that is in a man. The knights of ancient times had their tournaments to test their skill and ability. Business today is the jousting field for engineers. The qualifications for engineering and business success are much the same as Service demands in "The Law of the Yukon" when he says:

This is the law of the Yukon, and ever she makes it plain.
Send not your foolish and feeble; send me your strong and your sane.
Strong for the red rage of battle; sane for I harry them sore;
Send me men girt for the combat, men who are grit to the core.
Swift as a panther in triumph, fierce as the bear in defeat,
Sired of a bulldog parent; steeled in the furnace heat.
Send me the best of your breeding, lend me your chosen ones;
Them will I take to my bosom, them will I call my sons;
Them will I gild with my treasure, them will I glut with my meat:
But the others—the misfits and failures—I trample under my feet!

OCCUPATIONAL DISEASES

The Problems of Their Practicable Prevention in Industry

By F. ROBERTSON JONES

ASSOCIATION OF CASUALTY AND SURETY EXECUTIVES, NEW YORK, N. Y.

INDUSTRY has so many and such a wide variety of major problems these days that to many the problems presented by occupational diseases among workers may seem comparatively insignificant. This is, however, far from being the case. Either from the standpoint of cost or of social betterment the situation confronting many employers as a result of their growing liability to provide compensation for or pay damages to the victims of occupational diseases is equally as serious as the ever-increasing tax rates and the prospect of soon being compelled to contribute to unemployment insurance funds. Speaking as a representative of the largest stock casualty insurance companies of the country, I can assure you that these companies are well aware of the almost overwhelming burden of cost which seems about to be heaped upon industry by the general extension of the compensation system to cover occupational diseases of all kinds. Our companies, of course, have only what might be called an indirect interest in the problems you are discussing, but they will be adversely affected if necessary insurance costs grow so great that they will be "more than the traffic will bear." They are naturally tremendously interested in these problems and anxious to cooperate in their solution. It is my opinion, which I believe firmly to be well founded, that the primary essential in meeting the problems of occupational diseases is prevention. If these diseases, through engineering and the medical sciences, can be reduced to the level of exceptional misfortunes, the remaining economic and legal problems can be readily solved. It therefore seems to me that most intensive consideration should be given to this phase of the situation immediately by the outstanding experts of the country, so that suffering by workmen from preventable maladies may be reduced to a minimum and so that industry may not avoidably be drained of its resources. The character of this meeting and the program to be presented indicates clearly that The American Society of Mechanical Engineers is alive to the situation and has the cooperation of the medical fraternity in its most laudable objective of prevention.

The specific subject for discussion at this meeting is the "Engineering Aspects of the Prevention of Occupational Disease." It is not my purpose so much to enter into this subject as rather to lead up to it by calling to your attention some aspects of the problem not special to engineering but which industrial engineers should study and bear in mind.

From the start, it needs to be borne in mind that all forms of ill health—"occupational" or of ordinary life—to which industry in any wise contributes, as, for examples, through defective lighting or ventilation, or excessive exertions, or exposures to the inclemencies of the weather, are matters for prevention. That, however, is a cyclopedic subject. You have advisedly restricted your discussion at this session to the topic of *occupational* diseases—which I construe to mean—in popular phraseology—those diseases, not of ordinary life, chargeable to health-hazards which industry itself creates. Even that is too broad a subject for me to deal with in a brief introduction. Therefore I will restrict my remarks generally to prevention of occupational dust diseases of the lungs, with particular reference to silicosis—since those diseases, of which silicosis ranks first, have now given rise to a problem of such magnitude and pressing importance to industry as, temporarily at least, to relegate other occupational diseases to a position of relative immateriality.

From what I can learn the disease now known as silicosis is as old as history. But whether because of a recent increase through the use of modern machinery, or because of a growing public recognition of its seriousness, or because of these two factors in conjunction, and possibly others also, silicosis has now become a mortal menace to industry. Whether under a system of employers' liability for damages or under a system of compensation—"regardless of fault"—for occupational diseases, the cost of silicosis is becoming so heavy as to entail the rapid or gradual ruin of many industries, unless the incidence of the disease can be radically reduced. The cure of silicosis, once it has progressed beyond a very early stage, is, according to the preponderance of medical opinion, practically out of question. Consequently, for silicosis, *prevention* is most emphatically the primary and principal problem.

That problem has engineering, medical, economic, legal, educational, and political aspects—all of which need to be realized by all concerned in the task of prevention.

In its engineering aspects, the principal problem in prevention of silicosis is the removal or prevention of inhalation of dust. As a layman I cannot imagine how, practically, all dust can be removed or kept from inhalation. Therefore, primarily at least, efforts should probably be directed principally to the elimination of harmful dusts. Here you are confronted with several difficulties. The preponderance of medical opinion is that, of the inorganic dusts constantly generated in industry, only dust of free silica (silicon dioxide), and perhaps asbestos dust—and these dusts only when in minute particles—are harmful, that is, harmful in the sense and to the extent of causing specific disabling diseases of the lungs. But that is merely a majority opinion, from which there are dissents; and it is open to doubt. Only a few months ago a high authority[1] on this subject in Great Britain declared: "We need a scientific 'recessional' in which to reexamine with an open mind many of the generalizations now accepted as current coin in relation to silicosis and 'miners' phthisis.'" Moreover, silicosis is, in colloquial language, "all mixed up with" tuberculosis. Apparently, tuberculosis induces silicosis, and silicosis lessens resistance to tuberculosis, or something like that. But tuberculosis may be caused by organic dust or, for all that I can learn to the contrary, may be indirectly activated by other dusts. Consequently, how far all dusts, or, if not all, then what dusts imperatively need to be eliminated is, as yet, a problem to be determined largely by experi-

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[1] Prof. S. L. Cummins, Adviser to the British Tuberculosis Research Committee, quoted in *Industrial Medicine*, April, 1934.

mentation, not based a priori on present medical opinion, but on the results of experience—on the results in the way of reducing morbidity from the use of specific means for prevention, engineering means among others.

A problem of vital importance in the study of engineering means of prevention is the determination of what is practicable—economically and humanly. Economically, the best means for prevention may often be impracticable. Industry cannot afford to be continually replacing its machinery to experiment with the latest gadgets. It would be a jump out of the frying pan into the fire to load an industry to death to prevent exposure to an occupational disease; and some means of prevention may be such that the workmen simply cannot be induced to use them properly and consistently. This problem will be particularly acute in the smaller undertakings. What is practicable in large and well-organized establishments is often impracticable in minor operations. Thus in the prevention of lead poisoning, the well-established paint factories have been almost completely successful, whereas among the job painters the incidence of that disease has been very little reduced. Results will probably be similar as to silicosis. In South Africa, where silicosis seems to be concentrated principally in mines, generally large establishments, measures of prevention are succeeding in reducing the incidence of the disease, encouragingly; but in Cumberland County, New South Wales, where a scheme of compensation for silicosis applicable to such small-job trades as quarrying, rock drilling, sewer excavation, etc., is in force, it seems that little progress in prevention is being made, though strenuous medical means are resorted to. It may turn out to be a job for engineers to discover means for prevention of silicosis practicable for the "little fellow." At least that point will require study.

This question of what is practicable, as distinguished from the ideal, leads up to another aspect of the matter. In my opinion, besides studying the best practicable ways and means for prevention, engineers should also give consideration to the formulation of *minimum* standards, and to ways and means for procuring their observance. Authoritative formulation of such standards is needed for many purposes—to impress backward industrialists, to guide and support insurers in granting or refusing coverage, and to furnish a scientific basis for regulations to be enforced by public authorities. A code of such standards needs to be elaborate, so as to fit different conditions, and to be open to continual revision, to keep abreast with the developments of research and experience. A present obstacle to prevention, not often realized but of no mean importance, is that many states have laws which impose upon employers *indefinite* obligations for the protection of the health of employees, such as to provide "adequate" ventilation, and to do this where "practicable" and to do that where "reasonable," subject to liability for damages for non-compliance, leaving it to juries in litigated cases to determine what is "adequate," "practicable," or "reasonable" under the circumstances. How can any of you expect an employer to go to much expense to follow your advice when an ignorant and misled jury may mulct him in damages for not doing differently? In my opinion, it is practically essential to prevention by engineering means to procure the replacement of such laws as these by public regulations prescribing *definite* standards, for the development of which your cooperation is requisite, and to get rid of the disturbing influences of juries in determining engineering questions by means of the adoption of "compensation" as the exclusive remedy for occupational diseases, for which your assistance would be of great weight.

All this that I have had to say has been discursive as a whole and speculative in parts. I hope, however, that it will be of some use to indicate to you the ramifications of your subject and how the particular topics to be discussed today fit into the broad problem of prevention, in the solution of which technicians in many lines must all cooperate.

Harry Leigh Irwin

A BATTERY OF MACHINES THAT CONVERT SOLUTIONS OF CELLULOSE NITRATE OR CELLULOSE ACETATE INTO TRANSPARENT, FLEXIBLE FILM BASE. KODAK PARK, ROCHESTER, N. Y.

The Administration of OCCUPATIONAL DISEASE CONTROL

By ALBERT S. GRAY

CONNECTICUT STATE DEPARTMENT OF HEALTH

INDUSTRY, in order to stay in business and maintain its position in the economic world of today, must avail itself of all the materials and processes which have been shown to increase the efficiency and speed the output of its production.

New substances and processes and new uses for older ones are constantly being utilized by industry. New chemicals, plating solutions, dopes, solvents, degreasers, condensation products, varnishes, paints, lacquers, dyes, abrasives, and fabrics—substances used to increase and broaden production—are often employed without a knowledge of their possible effects upon health. A fire hazard is eliminated by replacing an inflammable solvent with one that is not inflammable, without the realization that there has been substituted for the fire hazard a hazard to health in the new solvent. And it is in the use of these new substances and processes (and some of the old) that the health of the workers is affected and occupational disease results.

This has been recognized by a number of states, and though compensation for occupational disease was originally limited to a few specific occupational diseases, schedules have been gradually enlarged with a tendency, perhaps, toward the blanket coverage which has already been adopted in a number of states. I am not, however, confining my discussion of occupational diseases to the limited compensation interpretation of them, but shall consider them in the broader aspect of the effect of industrial environment on health. Hayhurst defines occupational disease as "Injuries and disturbances of health contracted in industrial pursuits or other vocations in lives as a result of exposure to toxic agencies, infectious organisms, or other conditions inimical to health."

Unhealthful industrial environment not only causes specific occupational diseases but increases the incidence of disease among the general population.

The life expectancy of the industrial worker is several years less than that of those otherwise employed. Tuberculosis rates are much higher and pneumonia rates twice as high in the industrial group. Mortality rates for degenerative diseases are two to three times as high in the industrial group.

According to the 1930 Census there were more than 15,000,000 persons gainfully employed in manufacturing and mechanical industries and the extraction of minerals in the United States. And in these industries there are more than 900 occupations potentially hazardous to health.

The control of occupational diseases, therefore, may be seen to present a public-health problem of the first magnitude.

Mechanical engineers have a tremendous responsibility in the control of these diseases, for in the majority of instances this control is but the application of mechanical principles, whether it be enclosure, ventilation, or both.

The progress of accident prevention during the past ten or fifteen years has resulted in the saving of thousands of lives and millions of dollars. A much greater saving may be accomplished by properly administered occupational-disease control. There has not been the incentive to prevent the occurrence of occupational disease that has been accorded accident prevention, for an accident is self-evident; a man slips on the floor, falls, or is burned or caught in a press—there is no question that he is injured and how. Unfortunately, the conditions predisposing to occupational disease are more subtle. They are not so attention-compelling as an accident; they may appear only as increased labor turnover or decreased production. The effect upon the individual is not so self-evident, and so the cause of the condition is not so readily recognized.

There is nothing particularly arresting in the gradual loss of power in the hands of those absorbing lead; nothing to stimulate the interest, no startling appeal in the slowed gait and mental peculiarities of those exposed to certain solvents; the development of anemia and tiny hemorrhages in those exposed to other poisonous materials; or the gradual development of fibrosis of the lungs from exposure to certain dusts. The onset is gradual, the change imperceptible from day to day, until the individual either leaves to be replaced by another worker who passes through the same cycle, or remains at work under progressively lessened efficiency until he can no longer work or becomes a compensable case. If he leaves for employment elsewhere, he continues at work at lowered efficiency for a greater or less time, dependent upon how much of the material he has absorbed. The body is capable of wide adjustment to environment and much harm may be done before evidence of the condition is noted.

Occupational disease is not a new problem but it is only within comparatively recent times that we have attempted to measure, definitely and accurately, its relationship to industrial environment. We now know that there is a very definite relationship between the health of the individual and the environment in which he works. We have been able to establish the smallest amount of many of the materials used in industry that will affect health (which we have called the "threshold dose"), and when this information is not available, the amount which good industrial practice dictates; and we can now measure the exposure of the individuals to these materials to determine whether this amount is exceeded. We know the amounts of toxic materials and the processes that will affect health. We know that if these various materials and processes are not controlled they will seriously affect the health of the individuals exposed to them, and may even affect the health of the people in the community.

THE CONNECTICUT BUREAU OF OCCUPATIONAL DISEASES

Connecticut, in 1928, recognizing the tremendous importance of the effects of industrial environment on the health of the workers in the state, set up as part of the State Department of Health, a Bureau of Occupational Diseases under statute which provides that all cases of occupational disease be re-

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ported to the State Department of Health and which authorizes the investigation of conditions causing or suspected of causing occupational disease, and which further provides that reports of occupational disease or the results of investigations cannot be used as evidence in compensation claims.

This bureau receives and investigates reports of occupational diseases made to it in accordance with the statute; makes surveys and field studies of workroom environment, including special determinations of dusts, fumes, gases, or other toxic materials, measurements of ventilation, illumination, etc., or any condition or process thought to be affecting the health of industrial employees, to determine whether the environment is safe or where and to what extent a health hazard may be present.

It provides a central source of information for physicians, industry, or any agency interested in the cause, treatment, or prevention of occupational diseases. It maintains in this connection a reference library containing the most recent information relative to the effects of various industrial materials and processes upon health, and in addition, as part of the set-up, a well-equipped laboratory.

The personnel of this bureau comprises technically trained men, who in the aggregate possess a broad knowledge of industrial hygiene, of industrial materials and processes and their effects on health, and the capacity to interpret the result of a survey or study as a basis for recommendations for control.

BUREAU'S FINDINGS REPORTED TO INDUSTRY

Each industry in which a study or survey is made receives a complete report of the bureau's findings, presenting the results of actual physical and chemical determinations of the working environment and the exposures of the individuals engaged in it, with recommendations for the elimination or control of any hazard that may be shown to exist. Actual determinations are made of the number of dust particles per cubic foot of air and of the concentrations of toxic materials present in the air to which the individual is exposed. These procedures necessitate the application by specially trained technical personnel of precise physical and chemical determinations. But it is in the proper interpretation of these results that the existence or non-existence of a hazard is established.

It is impossible for a lay inspector to tell by mere inspection whether the dust or other toxic material in the air of a workroom is present in sufficient quantities and is of such a nature as to constitute a hazard, whether the protection afforded is adequate, or the ventilation sufficient. It is only by measuring the exposure to these materials and processes that we can know that the individuals exposed to them are subject to injury from them.

The reports of these investigations are not just mailed to the industry but are presented by a technically trained man and discussed with the officials and engineers of the organization. This information not only establishes the nature and extent of an existing hazard but provides constructive data which engineers can utilize for the control of the hazard.

Already the work of the bureau, with the assistance of the engineering profession, has resulted in definite improvement in working conditions, changes in processes, substitution of materials, and, in a number of instances, in the purchase of entirely new equipment, not as the result of any mandatory orders, but due entirely to the fact that these industries were given definite concrete information on the effects of the environment on health. The actual requests for this service from industry have been so numerous it has been necessary to schedule work months in advance.

I say "with the aid of the engineering profession" advisedly, for the work of the bureau in the control of occupational disease is to render the laboratory and field service necessary to make the determinations of workroom environment, whether they be dusts, fumes, gases, illumination, ventilation, or any material or process that may affect health—that is, to measure the exposure and determine whether the environment is safe and if a hazard exists, where and to what extent, and due to what causes, and to present recommendations for its control. If the control involves specific engineering problems, as it frequently does, that is the job of the engineer; the bureau makes no attempt to provide this type of service, so that in the final analysis engineers have a definite responsibility in the control of occupational disease.

THE RÔLE OF INDUSTRY IN THE CONTROL OF OCCUPATIONAL DISEASE

In any program for the control of occupational disease the cooperation of industry is essential. Possibly one of the principal reasons why industry has been less willing in the past to correct an environment hazardous to health is that little attempt has been made to provide it with definite data. Such changes as have been effected were largely accomplished as the result of arbitrary orders from a law-enforcing agency and no serious attempt had been made to establish the exact nature and extent of the condition.

Industry is penalized through compensation payments if its environment causes occupational diseases, and, if it can be definitely shown that a health hazard exists, realizes that it is a matter of good business to control the condition causing it. But no industry will cooperate to the extent of changing its processes, installing new equipment, substituting new materials, etc., on the mere opinion of a lay inspector that a hazard exists. Under such circumstances it will do only what it is compelled to do, particularly when information secured as the result of such inspection can be used against it either in the form of mandatory orders, claims for compensation or both.

With a set-up such as exists in Connecticut, where the law provides that the results of investigations cannot be used in compensation claims, with a specially trained technical personnel to make determinations and interpret the conditions found in industrial environment, industry is provided with just the information it has a right to demand before it is required to change its processes, substitute materials, or take other necessary control measures.

Actual determinations of exposures are made in the working environment, and industry is presented with definite concrete facts that not only establish a hazard where it exists but provide constructive data for eliminating it.

It is our experience that when industry is approached by a health agency in behalf of a health program and is presented with definite data regarding its working environment, in a spirit of service rather than law enforcement, with the assurance that the results of the investigations will not be used in furtherance of claims against it, it not only accepts the service as a matter of good business but actually requests the assistance of such an organization in the improvement of its general working conditions.

THE ENGINEER'S PAST

The engineer's part in a properly administered program is of vital importance to successful control of occupational disease conditions. As an integral part of the personnel of the Bureau of Occupational Diseases, the engineer can offer an important contribution in interpretation of some phases of data obtained

and in the development of recommendations for control of occupational disease hazards.

The field of occupational disease control is by no means confined, however, to that group which may give full time to this problem. With the awakening of industry to the necessity of providing healthful environment, the entire engineering profession has a large opportunity for constructive work. With the data at your disposal developed by the type of plant investigation I have outlined, you have new tools and more precise yardsticks.

In order to perform your part in the control of occupational disease you must be prepared to predicate your work not on the amount of air or material you remove but on the amount that is left behind and be prepared to meet a standard that will keep the working environment safe. To you we must look for the practical application of our findings and recommendations. It is you who design the machines and equipment for the use of these materials in industry.

There is, of course, a great deal of equipment used by industry that can be safeguarded in so far as the creation of occupational disease is concerned by additional protective equipment, but it seems to me that you should keep in mind as a future development the importance of taking care of the problem in the original design so that hazardous conditions may not develop. Why design a rock-crushing machine without proper dust-collecting devices, a degreasing machine which permits toxic quantities of vapors to escape, or an asbestos carding machine that subjects operators to 35 million particles of dust per cubic foot of air, when, after installation, these equipments will require additional devices to protect the worker, more expensive and less satisfactory than if the equipment had been originally designed properly to protect the operator?

Industry is very much alive to the necessity of providing safe working environment for its employees and you have a splendid opportunity through the exercise of your profession to profit and do your part in the prevention of occupational disease. An appreciation of the effects of these materials and the importance of such data as I have outlined is not only essential to the proper performance of your task, but will go far in convincing industry that the design and installation of protective devices is not a tinsmith's job but one for a competent engineer.

H. W. Fortey

WARNER & SWASEY NO. 5 UNIVERSAL TURRET LATHE AT WORK IN THE SHOP TURNING OUT A DOUBLE-END WORM OF A-1 STEEL FOR USE IN THE APRON OF WARNER & SWASEY TURRET LATHES

TOXIC DUSTS

Their Origin and Sources in Various Industries

By REUEL C. STRATTON

THE TRAVELERS INSURANCE COMPANY

THE SUBJECT assigned to me presupposes that many industrial diseases are produced through contact with or inhalation of industrial dusts of a toxic nature. Personally, I do not believe that the consideration of occupational disease prevention should confine itself to dusts alone; it should include all materials produced in such manner that they may be inhaled by a worker. The question of whether a material exists as a gas, a vapor, or a dust is but one of particle size and chemical make-up; but with materials whose source is in industry, it does not seem fitting to stop with substances commonly known as dusts and thus fail to consider those which usually exist as vapors.

It is a common fault to focus attention upon one object to such an extent that others of equal importance are thereby relegated to obscurity. For the present, pneumonoconiosis, or more particularly silicosis, occupies the center of the stage and possibly for the purpose of this meeting such importance is justified. However, the engineer interested in the control of occupational disease by plant equipment and operation must not forget that there are many occupational diseases produced through exposure to industrial dusts other than silica-bearing ones and to vapors, and that the control of these industrial diseases may be brought about through the application of the fundamental principles which will be propounded by other speakers today. At present and until new avenues of control are discovered, explored, proved, and utilized, the problem in many instances seems almostl acking a complete solution, but it is unquestionably true that certain occupational or industrial diseases need not occur. The engineering aspects of their control are so well known that in the hands of capable plant officials there can be little excuse for their occurrence. In the control of such diseases, industry today faces a problem, the solution of which rests in the hands of the scientist, the physician, and the engineer.

While the generation of dust in various types of industries has a more or less common mode of origin, namely, the production of finely divided material, yet it does not seem fitting to group industries together even though the operations producing dust are somewhat similar. Therefore, in this paper, operations will be discussed as individual to a general industry rather than as individual unto themselves and assigned to many industries. While this may produce some repetition of material, yet for the sake of those engineers who are especially interested in an individual industry, I feel the paper will have added value.

QUARRY OPERATIONS

Although the exposure in a quarry due to dust varies in severity based upon the chemical composition of the material being quarried, most operations are similar. Drilling operations, both well and small-bore, produce voluminous quantities of small particles of the material in which the operations occur. Air-flushed drills distribute these particles over a wider area than do water-flushed drills, but the offal from water-flushed drills dries and then becomes distributed in the air. When crushers are operated, either gyratory or jaw, dust is produced in an amount depending mainly upon the size of the unit involved and upon the fineness of the material which is being processed.

Sizing and screening operations also distribute dust, although they may not in themselves be producers.

SHAFT SINKING, TUNNELING, EXCAVATION, AND DEMOLITION

Drilling operations in all such activities afford opportunity for dust generation. Again, the exposure depends upon the type of rock encountered. Transportation of materials to and from the face or working area also allows dust to be distributed. Steam-shovel work in excavations exposes workers to dust clouds. In demolition work, the pulling of walls, the dropping of floors, the loading and unloading of debris causes the generation of much dust. Blasting operations when required not only generate dust through the action of the explosive itself, but may precipitate other settled dusts by the shock transmitted to the surrounding structures or areas.

STONE DRESSING AND FINISHING

When this activity is in conjunction with quarry operations, the same quarry items previously listed pertain. Stone dressing and finishing is probably one of the most prolific sources of dust known. At least the exposure is one of the most serious due to the intimate personal contact of employees to the area in which the dust is generated. Stone dressing promotes much hand-tool labor.

Surfacing work, both hand and machine, produces quantities of fine dust. Sawing, cutting, and channeling, as well as drilling, are also prolific sources of contamination. Hand chiseling produces a certain amount of fine dust but in this work the larger particle sizes usually predominate. Hand polishing produces some dust but only a very small quantity as compared to a mechanical polishing mill or jack. Even when wet polishing is done, the quantity of dust is only slightly reduced. Sandblasting operations, if not isolated, are dust producers. Such dust generation is cumulative, as the abrasive material is broken and forms a dust in conjunction with the material which is being blasted and eroded.

In addition to the operations indicated, workers themselves create a dust hazard by the blowing, by means of a compressed-air nozzle, of dust which has accumulated around the tools or operations.

BUILDING CLEANING

The cleaning of buildings by hand or machine may be considered a dusty operation. This is particularly true when sand blasting either by air or steam is employed. The seriousness of the hazard somewhat depends upon the type of material being cleaned. Naturally, this is additive with the dust from the sand used for blasting purposes.

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Nesmith, N. Y.

ELIMINATING DUST IN ROCK DRILLING

(The drill operates through a dust collector consisting of a metal cap connected by a hose line to a suction tank and dust catcher.)

MINING

The more common forms of mining are coal, feldspar, glass, sand, metals, mica, refractory materials, and talc. In any form of mining, dust is produced in the use of drills and excavation machinery. This is true even in open-pit work. The exposure varies according to the rock encountered. As in other cases, the use of wet tools does not entirely eliminate the generation of dust.

SAND AND GRAVEL DIGGING—FLINT AND SPAR MILLING

These two operations are oftentimes associated. Underwater sand and gravel production is relatively non-hazardous but the sizing and screening operation, even though upon moist material, may be a source of dust generation as the fine particles will collect on machines, ledges, and parts of the buildings and later be swept into the air.

When flint and spar milling is carried on either in conjunction with sand and gravel digging or with any other source of raw stock, the hazard varies, as has been previously stated, according to the composition of the material being handled. Practically all operations are sources of dust contamination. Primary crushers, either gyratory or jaw, produce dust; secondary crushers, screens, jigs, air separators, conveyers, and other types of machinery generally produce dust in air to a greater or less extent. Bagging, packaging, and shipping either as individual items or as bulk may produce dust. Spoil heaps unless salted down may generate dust when the ordinary land breezes blow over them.

CONCRETE PRODUCTS AND ARTIFICIAL-STONE MANUFACTURING

Mixing operations are dust producers in this type of industrial activity. Finishing operations if by sandblast or hand tools also produce dust.

BRICK MANUFACTURING

In the manufacture of brick as well as tile and terracotta articles there are several sources of dust generation. The clay-drying department, whether natural material is used or a mixed slip is used, produces dust when the dried materials are thrown into the air through handling. The dropping on the floors of small quantities of material allows it to become dry and then be dispersed in the air by workers walking or by transportation. Mixing operations give off dust. The operation of pug mills and brick molders may generate dust through the drying of the waste material. Storage departments may be a source of dust occasioned through the handling of material.

CEMENT AND LIME MANUFACTURING

When operating in conjunction with a quarry or mine, previous sources of dust listed under such headings apply. In addition, all crushing operations produce dust. The charging operations to burners either hand or mechanically done will create dust. The operations of the finishing and packing department where bags and barrels are packed, closed, crated, and shipped are a source of dust generation.

FOUNDRIES

The exposure to dust in foundry operations varies only slightly according to the type of foundry. A non-ferrous foundry may be little if any different on an overall exposure from a ferrous foundry. Sand-conditioning operations produce dust. The use of sand cutters or blenders, screens, riddles, slingers, grab buckets, and other conditioning machinery or operations may create dust. In molding processes the general work on the molding floor or the use of sand throwing and blowing machines may produce a hazard. The application of parting compounds to the mold may create a dust. This situation is naturally more serious when the parting material used is of high free-silica content.

Shake-out procedure, rattling and tumbling with or without air, sand-blasting, grinding, and snagging are dust-producing operations. Scratch-brushing work may generate dust.

As previously mentioned, sand-blasting generates dust under any circumstances. Charging operations in loading a cupola or any other type of furnace may generate dust in the immediate vicinity and later contaminate the remainder of the premises. The storage of raw stock, such as limestone, coal, sand, and pig stock, may through handling generate additional dust.

METALS REFINING—LEAD

In addition to the exposures enumerated under mining and ore production, there exist in the refining operation dusty exposures. Furnace operations, such as charging and drawing, generate dust. This is particularly true when all or portions of the charging material consist of scrap, such as storage-battery plates. Trucking of such may strew the fine material on the ground or floors where it may be picked up and thrown into the air by walking or by the wind. Skimming, reheating, and

sampling operations produce dust. The handling of the collected material in bag houses, flues, or Cottrell precipitators may create a dusty exposure which is particularly serious during the cleaning operations necessary to keep Cottrell precipitators or bag houses operating at proper efficiency. The transportation of materials in leaky containers, non-enclosed mechanical conveyers, or uncovered cars creates a hazard. Hand shoveling may produce dust in serious quantities.

MERCURY, ZINC, AND COPPER REFINING

The items enumerated under lead refining apply here also. In the production of zinc, one added exposure appears which is the dust produced in the blowing out of retort condensers, either by barring down or by "shooting" the condenser with a slug of water.

BATTERY MANUFACTURING—STORAGE AND PRIMARY

In the manufacture of storage batteries an exposure to dust exists in the preparation department. The handling, weighing, and mixing of the lead oxides either by hand or machine generates dust. In the pasting operations, either hand or machine, the material may be spilled upon the machine or the floor, become dried, and later be thrown into the air in the form of dust. The brushing of pasted grids will generate dust in a like manner. On the assembly line even when only hand operations are in progress, dust may be generated.

In the manufacture of primary batteries not only may dust be generated by metal-casting operations, but also in mixing, filling, and sealing.

CHEMICAL MANUFACTURING

It would be impractical to attempt to list all the operations in chemical manufacturing which may be dust producers. Here again the seriousness of the exposure depends upon the material handled and the amount of material that is thrown into the air. Chemical dusts, particularly some dye and dye intermediates, are positive sources of dermatitis where the dust generated lodges upon the skin of employees. It is sufficient to say that dusts are generated in the chemical industry and each individual operation requires study by itself.

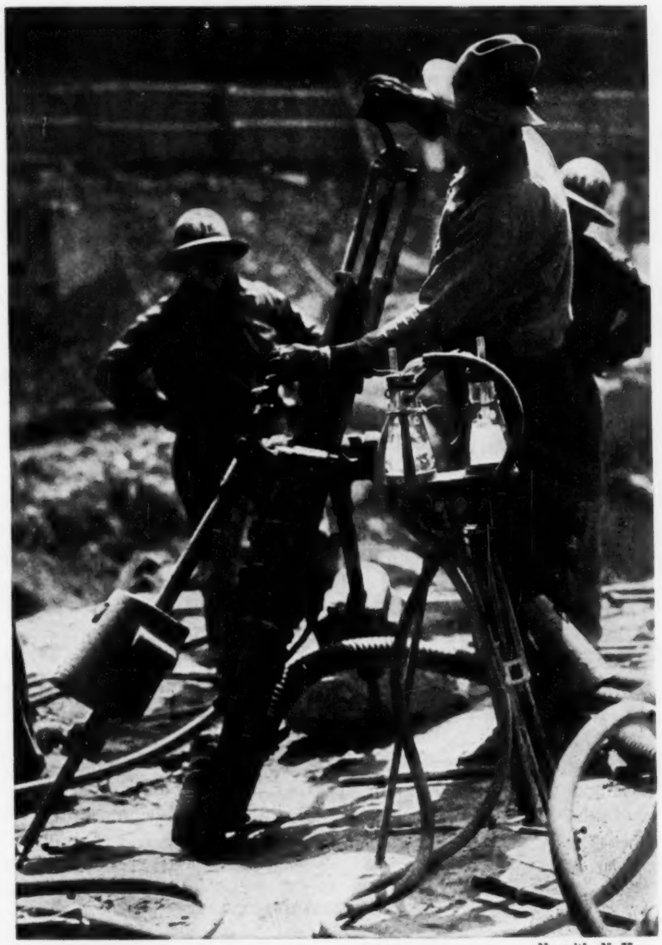
In chromic-acid manufacturing the sintering of ore is a dust-producing job. The handling and transportation of the ore prior to the sintering either in furnace or kiln produces dust. The quenching of the sintered material may generate dust as also the crushing of the sintered stock.

ASBESTOS AND ASBESTOS-GOODS MANUFACTURING

Any mining operations and quarry operations are exposures, as previously discussed. In the manufacture of asbestos goods, particularly dusty atmospheres are created in the break-out, opener, and picking operations. The crushing and grinding of the fiber, as well as all spinning and weaving operations, have a tendency to throw asbestos fiber into the air and create a source of dust contamination. Crushing and grinding asbestos products generates dust.

INSECTICIDE MANUFACTURING

The toxicity of any dust generated in insecticide manufacturing varies according to the material being processed. There is a similarity of operations in most insecticide manufacturing. The preparation department, where the raw materials are manufactured, involves dusty processes. The grinding of cakes from filter presses, the mixing of different ingredients, either by hand or machine, the packaging of the insecticides into bags, cartons, barrels, either by hand or mechanically, and the transportation of materials from point to point in the plant generate dust in varying degree.



Nesmith, N. Y.

ROCK DRILL MOUNTED ON TRIPOD AND EQUIPPED WITH DEVICE FOR THE ELIMINATION OF SILICA DUST

(The bottles shown on the tripod measure the amount of silica which would be inhaled by the drill operator.)

PAINT AND COLOR MANUFACTURING

The handling of bulk raw materials, as well as the grinding of filter-press cakes, will generate dust. Mixing and blending operations either wet or dry produce dust. This exposure is inherent in the handling of dry materials, but the spillage of water-wet materials may dry out and later be thrown into the air. Batch weighing when the handling is by hand produces dusty exposures.

GLASS MANUFACTURING

The most hazardous dusty areas in glass manufacturing are located in the raw-materials receiving department and the batch-mixing department. The unloading of glass sand, soda ash, spar, flint, and other materials from box cars or trucks into storage bins produces dust. Even when these materials are mechanically handled, dust is generated. Batch mixing where the various ingredients are drawn from storage bins and weighed preparatory to being transported to the furnaces also produces dust.

POTTERY MANUFACTURING

What has been listed for glass manufacturing also applies to pottery manufacturing. This is true even when a slip system is used. In addition, the grinding and kiln-firing operations are important sources of dust contamination.

ENAMELING AND ENAMEL-WARE MANUFACTURING

In the preparation of enameling material by mixing, grinding, in either bar or ball mill, blending, and solution-making dust is generated. Spray coating or dipping objects may create a dusty atmosphere through the dispersion of the fine droplets in air and drying out at the suspended material. The rimming of articles to produce stripes is a dust producer of high severity. Loading kilns for firing including the operation of continuous tunnel kilns may produce dust in large quantities. In such manufacturing as well as in many others, the transporting, storage, and handling of raw materials may be sources of dust.

TEXTILES

This caption also includes paper, linoleum, felt, hair, and other similar types of manufacturing operations. Such dusts are not generally considered as being toxic, but yet a sufficient number of instances have arisen to make it appear warranted to include them within the scope of this paper. Picking, opening, mixing, blowing, carding, willowing, spinning, and other similar operations produce dust. In linoleum manufacturing the receiving of the raw filler material, such as soapstone, talc, and mica, as well as the storage of these materials and their handling during process work, may produce dust. Both in hair and in hair-goods manufacturing, the dust may also include the spores of anthrax and the origin of such contamination may be particularly prevalent in the blowing and curling operations.

METALLIC-POWDER MANUFACTURING

Where a cupola is operated in connection with such operations, certain exposures previously listed may be found. In stamping the metal, dust may originate. In coating operations dust also occurs. Where an air-float method is used for the separation of fine particles from large, dust may be exhausted into the atmosphere of the place of work in copious quantities.

MISCELLANEOUS EXPOSURES

There are certain exposures where a material may exist in the form of a dust, a vapor, or possibly a spray of fine droplets. The correction of any exposure of this type requires recognition on the part of the engineer of the material to which workers may be exposed and a determination of the point of origin of such material. A few miscellaneous exposures are discussed in the following paragraphs.

Exposure to Mercury. Exposures to mercury may occur in the mining of the ore, the reduction of the ore, and in the amalgamation of gold ores. Exposure is also found in the manufacture of thermometers, vermillion, and other dyes, the felt-hat industry, the treating and handling of furs; incandescent-lamp, radio-tube, and other electrical-apparatus manufacture; explosives manufacture; and laboratory work, including photographic and research laboratories.

The exposure may be from the dust of the salts of mercury, the generation of fine droplets of mercury together with dusts of other nature, and the vapor of mercury which is generated at high temperature as well as small amounts which may be given off at ordinary room temperature.

Exposure to Chromium. The exposure to chromium is usually found in the generation of the dust of the salts of chromium. There are certain processes in the manufacture of chromic acid and chromium salts from chromium ores which produce dust. The manufacture of paint pigments containing chromium, yarn dyeing and calico printing, the use of bichromates in dye preparation, the chrome process of leather tanning may also have dusty operations. In electroplating with chromium many fine droplets of chromic acid may be thrown into the air by the bubbles of hydrogen disengaging at the surface of the liquid in the electroplating tank.

Exposure to Benzol. Exposure in the case of benzol is usually due to the vapor of the material. The operations of its production, its use in artificial-leather manufacture, in degreasing operations, and in others may result in an exposure. Information may be found in the report on benzol which was published several years ago by the National Safety Council.

Exposure to Lead. As lead is used in widely varied operations and in widely varied forms, it would be relatively impossible to list all of the operations which might include an exposure. The exposure usually exists in the form of dust of the material itself or its compounds or in the form of fumes which may be generated at points where the material is handled at temperatures above its melting point.

Dusty operations may occur in lead mining, lead refining, lead smelting and sintering, the manufacture of plumbers' supplies, foundries, battery manufacture, both storage and dry, pottery operations, glass manufacture, certain printing trades, rubber-tire manufacture, and paint manufacture. In addition, dusty exposures may occur in the chemical-manufacturing trades which involve the manufacture or use of lead or its compounds.

Exposure to Arsenic. Exposure to this material may often be found in the dusty operations surrounding the refining of copper ores and the manufacture of insecticides containing arsenic, either in the form of the oxide or other salts.

Exposure to Radium and Radioactive Substances. The exposure to this material while not by any means general has been recognized in isolated sections and attained for itself relative prominence. The exposure may exist in the inhalation of dust from radium-bearing materials or the exposure to and the inhalation of emanations from radium. In general, this exposure is produced in the mining and handling of radium ore, the refining of the ore, the collection of radium emanation, and the use of the material in producing luminous dials for watches, clocks, and instruments.

CONCLUSION

One should not necessarily conclude that every operation listed in this paper is an absolutely dangerous source or point of origin of a toxic dust. It should not be a foregone conclusion that the operations listed in this paper include all of the possible sources of toxic dusts. The operations discussed, however, are typical of those where known cases of exposure have occurred. To the engineer unfamiliar with sources of air pollution, even in the so-called non-hazardous industries, the listing may seem far-fetched and ambiguous. It should not be assumed that an exposure listed in this paper is prima facie evidence that trouble is inevitable, but to an engineer interested in protection against the more important sources of air contamination by dust generation from ordinary industrial procedure, the listing will provide a basis upon which he may work. All in all, it is best for any engineer to proceed upon the basis that any dust of any type in any concentration creates an industrial exposure and to suppress the dust at its origin.

PROGRESS *in* POWER

A Review of the 1934 Progress Reports of the A.S.M.E. Oil and Gas Power, Hydraulic, Fuels, and Steam Power Divisions

By C. F. HIRSHFELD

DETROIT EDISON COMPANY

THE economic conditions which have existed during the past year have not been favorable to the installation of new power-generating equipment. This is reflected in the comparatively small number of new installations made and correspondingly in the dearth of new developments that have been put into practice.

DIESEL ENGINES

One very marked exception to this general rule is furnished by the Diesel-engine industry. After a steady, non-spectacular development in Europe, the recent progress of the Diesel type in this country has been almost spectacular. One can but conclude that it has finally demonstrated its ability to meet the specific needs of certain fields of usefulness in spite of the general prejudice against it that has existed here for many years. I think this is, in fact, a true statement of the situation.

The outstanding developments have been:

(*a*) Increase of rotative speed, yielding lighter weight or greater power per unit, depending upon how utilized.

(*b*) The very general use of superchargers with results similar to those produced by increased speed.

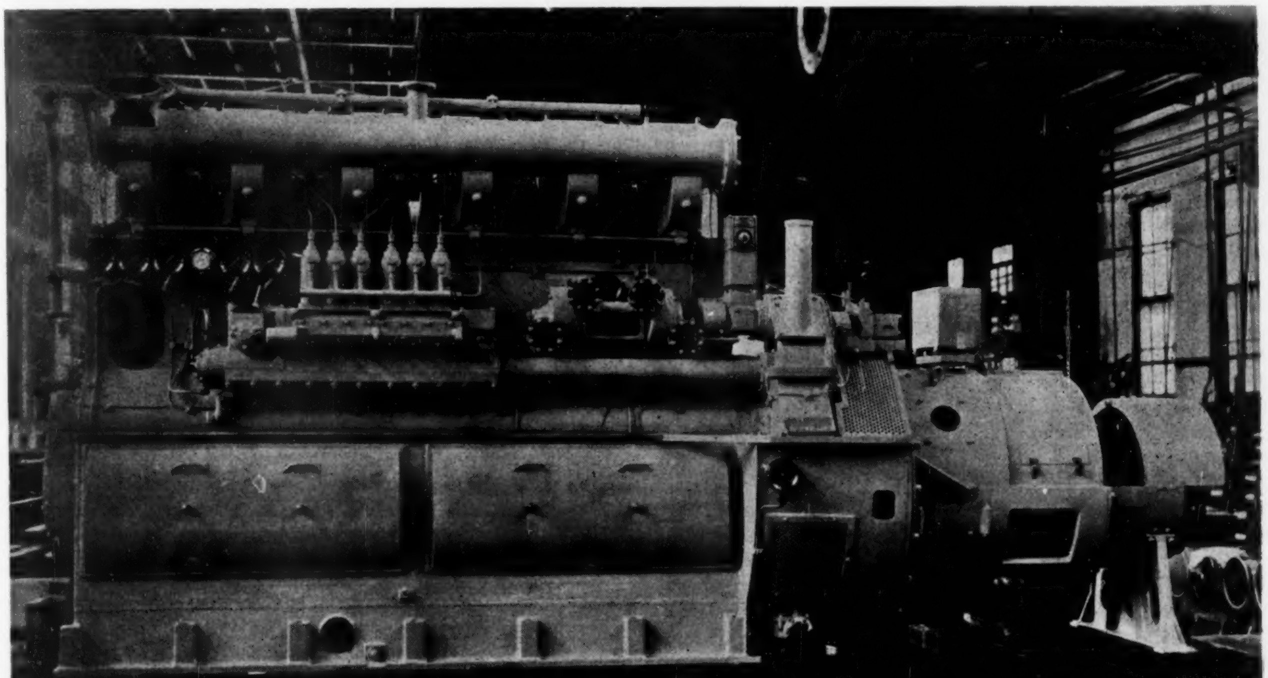
(*c*) Improved design of parts and the use of materials better adapted to the conditions to which they are subjected, resulting in improved performance and lessened maintenance.

(*d*) The use of mechanical as against air injection, greatly simplifying the installation.

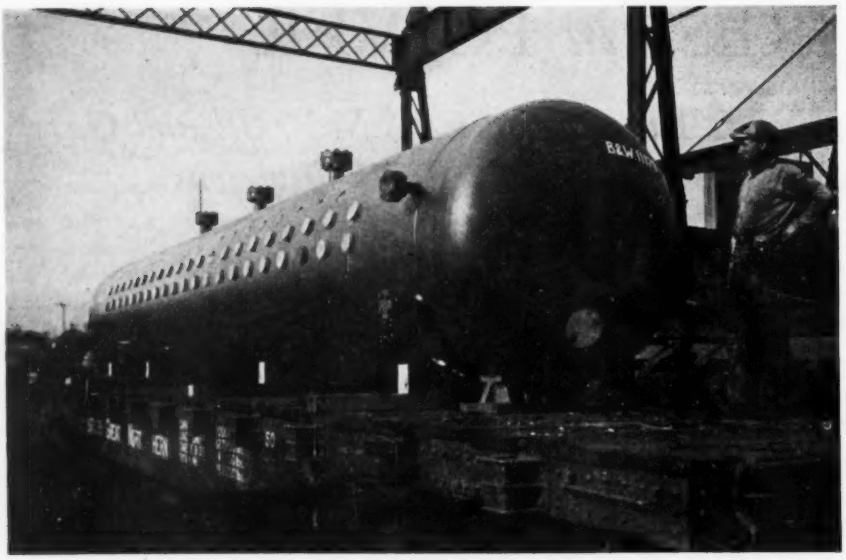
The Diesel is finding its greatest fields of usefulness in transportation, and small or comparatively small stationary power plants. Under the first heading are vessels varying all the way from transoceanic liners and tankers through work vessels of various sorts to small pleasure craft; railroad trains, single rail cars, and single locomotives; and road vehicles, such as trucks. In all these applications low overall weight of plant and high fuel economy are obviously the governing considerations, now that the engine has been given the required reliability and flexibility at an acceptable first cost and maintenance cost.

The use in small and comparatively small stationary power plants results from the greater simplicity of a plant of this type when compared with an installation involving the use of steam boiler and steam prime mover of presently available designs,

Presented at the Annual Meeting, December 3 to 7, 1934, of The American Society of Mechanical Engineers.



LATEST TYPE MCINTOSH & SEYMOUR DIESEL-ELECTRIC UNIT FOR THE COAST GUARD CUTTER "HUDSON"



WELDED DRUM FOR BABCOCK & WILCOX BOILER

(Weight of drum, 106,800 lb; inside diameter, 60 in.; length over heads, 37 ft $1^1/_4$ in.; straight length, 34 ft $3^1/_2$ in.; thickness of plate, $3^{11}/_{16}$ in.; working pressure, 800 lb per sq in.; pounds of steam per hour, 320,000.)

combined with the higher net thermal and economic efficiencies obtainable with the Diesel in such installations in favorable locations.

It is of interest to note that light and power companies are finding that in certain cases a better economic result is obtained by installing locally a Diesel-electric plant than would be obtained through the extension of transmission lines from existing plants of larger size. This is but another example of the constantly shifting economic picture that results from man's continued effort to develop new and better methods of supplying his needs. To me the general proposition appears particularly significant in view of certain contemporaneous activities of our Federal Government.

Possibly it is not proper to put predictions into a summary of accomplishments. But, I believe the broad purpose of such meetings as this is not only to tell what has been accomplished but also to do what can be done to advance the industry of the country and thus to improve its economic status. Believing this, I feel it proper to depart somewhat from a rigid and literal interpretation of my assignment.

I suspect that before very long the Diesel plant is going to meet a formidable competitor through what appears to me to be a rational further development of the high-pressure and high-temperature steam plant. I can picture a small and cheap, automatically operating plant of this type capable of utilizing fuels that are even cheaper than those available for Diesel-engine use. The thermal efficiency would be lower than that attained in the Diesel plant, but I suspect that the economic efficiency would be substantially the same. At any rate, here is an opportunity that I believe worthy of study and possibly of development by one or more enterprising manufacturers.

HYDRAULICS

It was not so very long ago that many people believed hydraulic engineering had about reached its maximum of achievement. The almost stationary maximum efficiencies and the huge capacities of single units were taken to justify such a conclusion. Once more the restless and ever-progressing spirit of man was overlooked.

There has been marked progress in the development of new types of pumping equipment and in the improvement of hydraulic-turbine design. In addition, advances have been made in the studies of water hammer, water measurement, flow of water in conduits, cavitation in hydraulic equipment, and in other directions.

There appears, in fact, to have been a renaissance in hydraulic laboratory and research activities, with the result that many avenues for worthwhile advance are indicated.

It is notable, in this connection, that research has not only shown the commonly accepted explanation of cavitation phenomena to be incomplete but has also indicated means of minimizing the effects of cavitation on both the performance of power and pumping units and on their maintenance.

There have been many important advances in water-pump design and fabrication. Motor and steam-turbine-driven centrifugal pumps have shown efficiencies of the order of 90 per cent. The axial-flow, propeller-type pump has been further improved and is rapidly coming into favor for low-head work, including the circulation of condensing water in large steam power plants. Moreover, the head against which such pumps may work effectively is being increased as their characteristics are becoming better understood.

To one who happened to be associated in a small way with the introduction of the multi-stage, high-head centrifugal pump in this country some thirty-odd years ago, it is of particular interest to note the presently successful use of this type for heads of 3000 to 4000 ft. At the beginning of this century we were struggling with heads measured in the early hundreds instead of thousands.

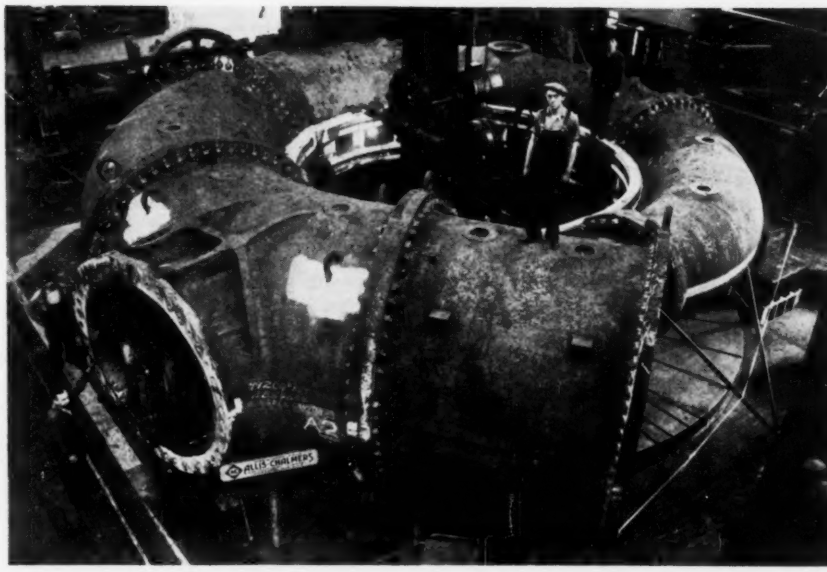
The large public-works program of the Federal Government has given a new impetus to hydraulic-turbine design and several new units of record-breaking size and capacity are called for. The turbines for the Boulder Dam power plant are rated at 115,000 hp under a nominal head of 530 ft. These units are to operate at 150 rpm. They represent great improvements over previous practice in many respects, including better provisions for maintenance. Another notable unit is a turbine ordered by the Tennessee Valley Authority. This is of the propeller type and the largest of its kind yet attempted in this country. The throat will have a diameter of 268 in. The capacity will be 45,000 hp under a head of 48 ft when operating at a speed of 85.7 rpm.

The Kaplan type of hydraulic turbine is finding increasing favor, particularly in plants required to run under very wide variations of discharge. It is reported that turbines of this type and of larger size and greater capacity than heretofore constructed in this country are being considered for the Bonneville plant on the Columbia River.

STEAM POWER

There have been no revolutionary developments in the field of steam power. On the other hand there has been a continuing evolution toward the common acceptance of high steam pressures and high steam temperatures. Steam pressures

up to about 1400 lb may now be considered as normal instead of partly experimental, both with respect to industrial and to public-utility plants. The steam temperature has been stepped up more or less rapidly from the region of 700 F to something of the order of 850 F. Higher temperatures are to be expected as experience is gained and as the necessary alloys become available at sufficiently low prices. It is significant that at least one manufacturer expresses willingness to construct a 200,000-kw turbine to operate with an initial steam pressure of 1200 lb and a steam temperature of 1000 F. The unit would be of the tandem type and would operate without reheat.



ONE OF THE FOUR SPIRAL CASINGS OF THE 115,000-HP TURBINES FOR BOULDER POWER PLANT

(The casing is under the Allis-Chalmers boring mill for machining center portion. Weight of complete casing approximately 450,000 lb.)

The ability to utilize high steam temperatures is gradually but certainly bringing about the common use of installations in which high steam pressures are used without reheating, thus producing a reduction in complication and first cost. In fact, it seems as though the arrangement now most favored for highly efficient steam stations may be described simply as the use of the highest steam pressure that can be utilized safely without reheating and with the highest steam temperature that the designer believes proper for the given conditions of use. At present, commercial installations are generally limited to steam temperatures between 800 and 900 F, with steam pressures in the range from, say, 600 up to 800 lb. The use of 1400-lb steam with an initial temperature of 900 F on a 100,000-kw unit as ordered for the River Rouge Plant of the Ford Motor Company and to be operated without reheat in spite of an expected vacuum of the order of 1 in. Hg indicates how far the turbine manufacturer is willing to go in the elimination of reheat. However, the recent installation of at least one major reheating plant at 1400 lb should be recorded.

It should be noted that one of the essentials for satisfactory operation at high initial temperatures is a very constant steam temperature. Much ingenuity has been displayed by designers and manufacturers in producing equipment that will achieve this result.

The availability of equipment which will permit the use of high pressures and temperatures without reheating is having a very noticeable effect upon the rehabilitation of existing steam plants. The superposition of high-pressure and high-temperature equipment exhausting into the older equipment permits the increase of capacity of old stations and a measurable increase of overall net thermal efficiency while salvaging much of the existing investment. It appears as though this method will be used extensively in the near future.

Great improvements have been made in the conditioning of feed and boiler water for operation at high pressures. Such conditioning is a matter that should not be overlooked in planning any high-pressure installation.

A tendency in boiler design which has been noticeable for several years, namely, the use of completely water-cooled furnace walls, small boiler heating surface, and large heat-recovery surface in economizers and air preheaters, continues. Also the use of welded construction for drums, headers, and other parts is making rapid progress. A notable accomplishment in this direction is the drum for a boiler ordered by Firestone Tire and Rubber Company. This unit is to produce 300,000 lb of steam per hour at a pressure of 1400 lb. The drum is welded throughout. It is 4 in. thick, has a length of 23 ft, and an inside diameter of 54 in.

The announcement by Westinghouse Electric and Manufacturing Company of the rights for the development of the Benson-type boiler plant in this country marks another stepping stone in the high-pressure field. This boiler was developed for use at or above the critical pressure, but it is reported to have been used in practice below that pressure with good results. One of the latest proposals is a unit of boiler and turbine with the output of the turbine controlled by variation of the boiler pressure. This opens up what may prove to be a fruitful field.

The Loeffler type of boiler in which evaporation is produced in an unfired vessel by means of highly superheated steam is gradually finding acceptance in Europe. No installations have been made in this country. A recently reported authoritative test of such a boiler in Europe indicates an acceptable thermal performance. Little factual information is available regarding maintenance and possible operating difficulties.

Fuel-firing equipment has made slow advance along lines indicated during the past few years. The notable development in underfeed stokers is the successful use of zone control of air supply in several large stoker installations. Although this practice started several years ago, it spread very slowly because of initial difficulties and because of the increased complication. It may now be said to be an established arrangement.

A new control unit has been developed for hydraulically operated underfeed stokers which automatically reverses the movement of the ram in case the forward progress of the latter is impeded by an obstruction.

In the field of pulverized-fuel firing there appears to be a definite swing toward the unit mill or mills as against the central preparation and storage system. There also appears to be an increasing tendency toward the use of the slagging type or slag-tap type of furnace. A movement toward larger fuel capacity per burner has been obvious for years. The latest achievement is a burner at the West Virginia Pulp and Paper

Company which burns sufficient coal to produce 135,000 lb of steam per hour, representing a heat liberation of about 205,000,000 Btu per hr.

An interesting and undoubtedly valuable development is an arrangement by means of which coal pulverizers can supply pulverized fuel satisfactorily at low ratings, as for example during week-ends, lunch hours, etc. In this arrangement more than the required amount of fuel is taken from the mill. That required to carry the existing load is fed to the burner and the surplus is returned by a bypass to the pulverizers.

Advances in methods of, and equipment for, power generation are in many respects intimately tied to advances in metallurgy. This is particularly true at the present time because of the efforts to use higher temperatures, higher pressures, and higher speeds, while at the same time reducing maintenance, or, at least, not increasing it.

The advent of stainless steel and of numerous other alloy steels has contributed greatly to the improvement of power-generation equipment, hydraulic, internal-combustion, and steam. Much remains to be done, but the rate of progress is now high and new developments may be expected frequently.

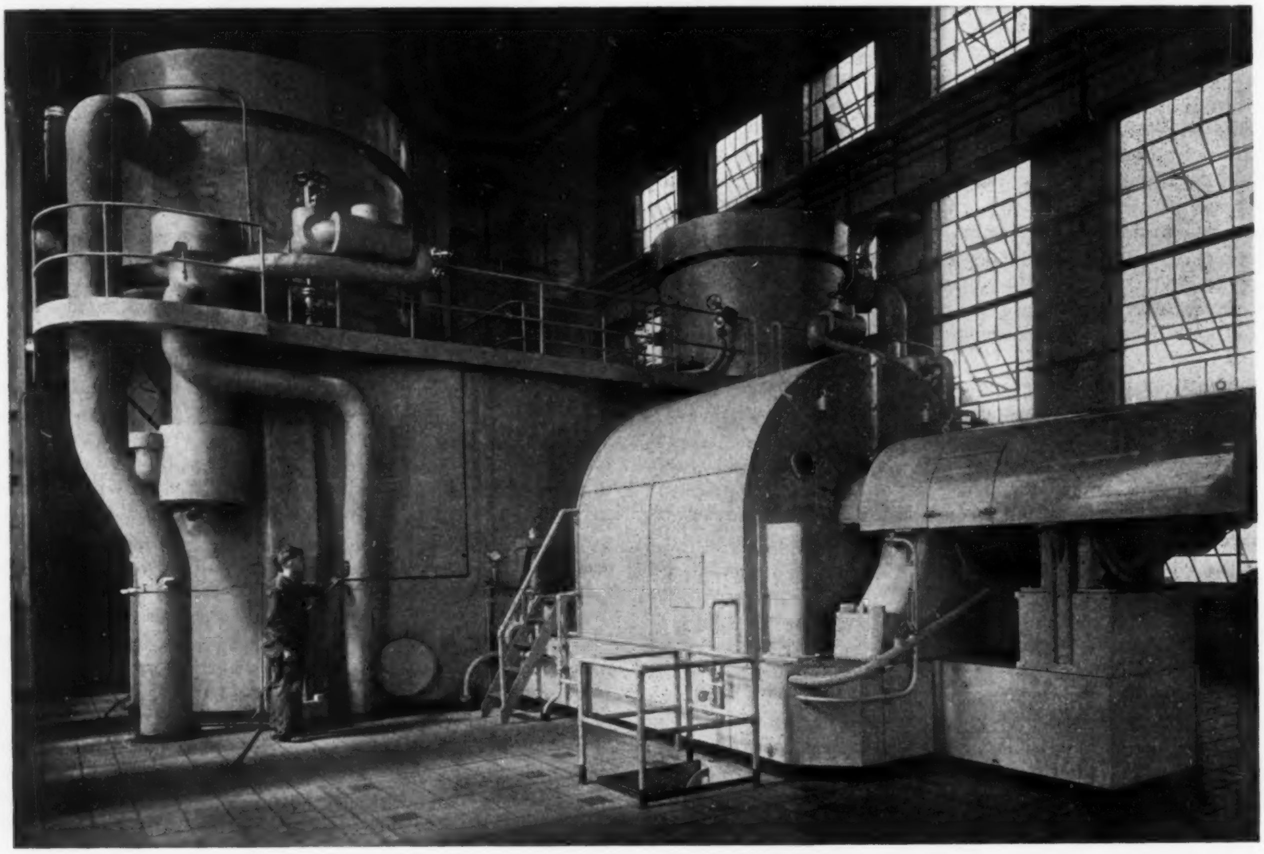
One rather astounding metallurgical accomplishment is the production of heat-treated alloy "cast iron" which has remarkable properties not commonly associated with cast iron. It is more nearly a cast steel than a true cast iron if one defines on the basis of total carbon. The fact that such material is being used successfully for the crankshafts of automobile and high-speed Diesel engines indicates in a striking way the astounding results that flow from modern research.

Reference has been made to the fusion-welded drum of a high-pressure boiler purchased recently. In spite of the short time that has elapsed since provision for such fabrication was included in the A.S.M.E. Boiler Code, it is now standard practice in the industry. Tremendous advances have been made in both welding methods and means for checking the completed welds.

Concurrently, there has been a rapid increase in the use of welded joints in steam lines and in other pressure-carrying parts. One notable development in this connection is an electrically heated annealing equipment adapted to anneal welded pipe joints in situ.

Welding is also coming rapidly to the fore in the construction of many parts of prime movers of all sorts. "Fabricated" hydraulic equipment, engine frames, bed plates, condenser nozzles, and condenser shells are now commonly used in place of the more conventional cast iron or cast steel. The general acceptance of this method of production is also reflected in the wide use of welding for maintenance work of all sorts in all types of power-producing plants and equipment.

Few engineers failed to follow the rapidly falling graphs or tabulations of fuel output and power output that marked the progress of the depression toward its depths. It is significant that during the current year these criteria have indicated a reversal of conditions and a gradual upward climb. Progress has been erratic, with marked ebb and flow, but the integrated result is at least encouraging. On this basis both fuel output and power output show material increases over the immediately preceding period. We may at least hope that this phenomenon will continue; that is, that it may represent more than a purely temporary change of basic economic conditions.



GENERATOR END, NO. 1 MERCURY UNIT, KEARNY GENERATING STATION

The Application of

CENTRAL-STATION PRACTICE *to* DOMESTIC HEATING

By M. K. DREWRY

MILWAUKEE ELECTRIC RAILWAY & LIGHT CO.

THIS PAPER shows that the application of central-station practice to domestic heating results in important improvements. One of the greatest improvements accrues from using the central-station principle of automatic stoking.

A specially constructed residence heating plant using solid non-caking fuels and applying many central-station practices has afforded the following experiences:

(1) A boiler-plant efficiency of 90 per cent is averaged for the heating season by maintaining 10 per cent CO_2 and 160 F flue-gas temperature at the smoke-pipe outlet.

(2) A continuous year-round fire is maintained to eliminate starting new fires and to heat service water in summer. Boiler-rating averages as low as 5 per cent of designed capacity for as long as a week without attention. Chimney draft is often negative during warm days, yet fire maintenance is continuous at a combustion rate of only $^1/_4$ lb of fuel per sq ft of grate area and an overfire air temperature of less than 200 F.

(3) The use of a boiler of half the usual size is made possible and practicable by stoking the fuel by gravity, as needed, from an external hopper.

(4) Air leakage is maintained continuously low by initial testing and permanent prevention, which aids efficiency and regulation.

(5) Use of the smoke pipe as an efficient air heater, by simply making it airtight, reduces the flue gases by 300 F at high ratings and supplies necessary heat to the basement.

(6) Attention to ash flow below the fuel bed results in an average of 7 per cent combustible in the ash and therefore less than 1 per cent loss in the refuse.

(7) Keeping the stoking hopper airtight prevents burning-back of the fuel into the storage coal. Ventilation of the hopper with flue gas eliminates condensation on the hopper walls.

(8) Employing a small amount of water as a heat-exchange fluid between the fuel-combustion and air-heating processes affords accurate maintenance of room temperature and ability to furnish heat rapidly without temperature over-runs.

(9) Minimization of oxygen absorption by the boiler water renders it non-corrosive.

(10) Use of water as a heat-exchange fluid isolates fuel combustion and air heating in separate casings, thus preventing contamination of the heated air with fumes. Water maintains low fire-pot-metal temperatures, minimizes maintenance costs, and permits permanent airtightness.

The safety aspects of solid fuels, which are unusually important in domestic heating, are discussed. The rapid adoption of the automatic domestic stoker within the last few years is cited as proof of its desirability. The smoke-abatement aspects of better firing methods are also presented.

THE INSTALLATION

Figs. 1, 2, and 3 show the installation of the domestic heating plant upon which the tests described in this paper were conducted and the house in which it was installed. It replaced a standard warm-air furnace, but utilized the same air pipes. Its performance was studied in detail for an engineering thesis,[1] and its air-conditioning aspects were reported in a paper before the American Society of Heating and Ventilating Engineers.[2]

To date, the unit has served during one and one-half seasons of heating and two summers of service-water heating. Daily data were kept for three heating months. A summary of operating data for March and April is listed in Table 1, excluding fuel consumption and ash accounting which appear separately in Table 3. Fig. 4 shows daily averages of flue-gas CO_2, sampled at the smoke-pipe outlet by uniform collection every 24 hours into a bottle by gradual water displacement.

TABLE 1 SUMMARY OF MARCH AND APRIL OPERATING DATA

Averages of Daily Readings

Month, 1933	March	April
Coke burned, lb	111	73
Ashes removed, lb	8.6	4.8
Humidity water evaporated, lb	39	28.8
Energy used by fan, kwhr	0.66	0.3
Number of thermostat operations	26.5	20
Flue-gas analysis:		
CO_2, per cent	9.0	10
O_2, per cent	....	10.15
CO, per cent	....	0.20
Relative humidity in rooms, per cent	43	49
Outdoor temperature, F	32.7	43.8

Daily records were substantiated by special tests to indicate that the average heating-season boiler efficiency reaches 90 per cent, if radiation losses to the basement are credited to the unit. High fuel economy was important because an attempt was made in designing the plant to limit investment and operating costs of complete air-conditioning, including summer cooling, from exceeding total costs of the displaced simple equipment. Table 7 shows how nearly these results were accomplished.

Contributed by the Fuels Division and presented at the Annual Meeting, New York, N. Y., December 3 to 7, 1934, of The American Society of Mechanical Engineers.

[1] University of Wisconsin, 1933, for degree of mechanical engineer.

[2] Presented at 40th Annual Meeting, 1933. See *Heating, Piping, and Air Conditioning*, January, 1934.

BOILER SIZE

Summer-time boiler operation and economic considerations prompted the choice of a boiler of about half the conventional size, the principal design data for which are given in Table 6. The choice of such a boiler resulted in an average heat-transfer rate 5000 Btu per sq ft per hr as compared with 2400 and 10,000 Btu per sq ft per hr, respectively, for domestic practice[3] and central-station practise.[4] Since average domestic loads are only about one-third of maximum capacity, compared with a corresponding ratio of about two-thirds for central-station boilers, domestic boilers appear greatly oversurfaced. Lack of cleanliness, use of high excess air, need for fuel-storage capacity, and poorer heat absorption due to lower mass-flow rates, result in using the equivalent of four times as much heating surface in domestic boilers as in central-station boilers. With this fact in mind, a small boiler was chosen for the unit under discussion.

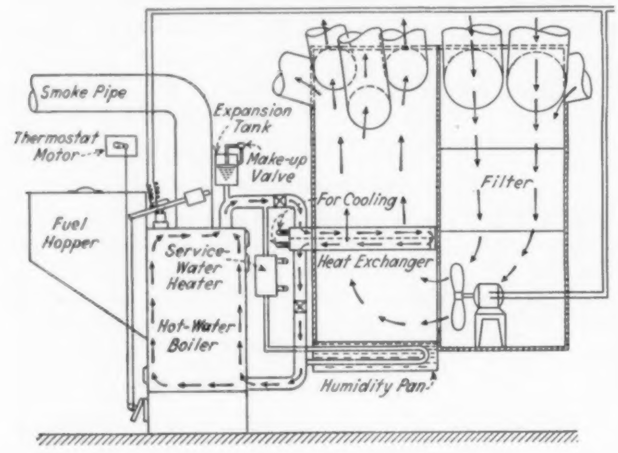


FIG. 1 AIR-CONDITIONER DIAGRAM

(Flow circuits of air and water in this combination hot-water and warm-air system are indicated. It displaced a warm-air furnace but used the same leader pipes.)

This choice, however, necessitated external storage of fuel to eliminate frequent stoking periods, especially since fuel of low density (coke) was to be used. Gravity feed from an external hopper was selected because of the simplicity of its operation and freedom it affords from the need to regulate the fuel-bed height and air flow for efficiency. The fuel bed of non-caking fuel may be thought of as an efficient oxygen filter, always adjusting itself for about the same oxygen removal throughout the grate area. Thus, higher combustion at one point soon reduces air flow by formation of more ashes, causing an equilibrium of conditions in the furnace that result in flue gases of high CO_2 content and low stack losses. During the tests made on the unit mentioned, 17 per cent CO_2 has often been observed without presence of CO, and 10 per cent CO_2 has been sustained at 5 per cent boiler rating. Since the high boiler efficiencies, possible with non-caking fuels, pay for their extra cost in this case, one desirable solution of the community smoke problem is indicated.

In spite of the relatively small boiler, heat-absorption performance was found to be comparable to that of power boilers where better results are usually justified. Boiler outlet temperatures of 667 F for maximum capacity and 325 F for average heating-season output which were attained are representative of good performance of large boilers. The fuel used is credited with this gain, because the continuous equilibrium conditions of low excess air (high CO_2) that result from its use cause maximum radiant-heat absorption in the firepot and therefore minimum flue-gas losses. This same influence, causing a small weight of flue gas, was also largely responsible for limiting the flue-gas temperature at the smoke-pipe outlet to 361 F at 100 per cent rating and to average 160 F for the heating season. Dry flue-gas losses up the chimney averaged less than 5 per cent, a value which few large central stations achieve.

[3] A.S.H.&V.E. Guide, 1933, page 211.

[4] Lakeside station.

EFFICIENCY TESTS

Besides keeping daily data for the heating-season months, special tests were performed at approximately 25, 50, and 100 per cent capacity. Table 2 summarizes the data taken during these tests and Figs. 5 and 6 show the principal results. Combustion rate was regulated automatically, and no special attention was given the apparatus except during the test at 100 per cent rating when overfire air was admitted to reduce CO losses.

The efficiency of the unit was determined by the heat-balance method, for the losses were relatively small and were determined with fair accuracy. Output and input data during the 10-hr 100 per cent rating test indicated an efficiency that was 10 per cent too high, apparently because of differences in the fuel bed when starting and stopping. Crediting boiler radiation losses, and using a fuel with only 1 per cent hydrogen loss, gives this small installation a 5 per cent efficiency advantage over large central-station boilers. Since many central-station boiler units have averaged over 90 per cent efficiency, the performance of this unit is not unusual.

AIR LEAKAGE

Domestic heating with solid fuel would profit much were installations positively airtight from the ashpit door to the chimney top, similar to the modern central-station boiler units. Domestic practice has always sanctioned the expensive and ineffective method of bleeding room air into the smoke pipe and chimney to reduce combustion rate, instead of stopping air flow by positive airtightness of the ashpit and firepot. Attendants are compelled to regulate heat output by judicious attention to shaking of ashes, for ash beds can become almost airtight and will prevent air flow induced by the relatively high stack effect inside all fuel-burning equipment. Check doors admitting air at the top of boilers are useless when attempting to prevent this important internal draft.

Admitting air over the fire reduces the draft within the boiler, but at an enormous cost. A survey of dry chimney losses in actual residence installations would show an extremely wide spread between published tests of laboratory performance and field performance. To regulate a fire at 5 per cent of normal rating under conditions varying from high chimney drafts due to winds, to negative chimney drafts due to high outdoor temperature, requires airtightness of all parts. In the unit on which tests were run, a summer fire has maintained itself at about this rating for 9 days without any attention other than adding coal to the hopper (which would have been unnecessary had the hopper been filled at the beginning of the test). At times of negative chimney draft, pressure formed by the heated column of air within the boiler itself, forces air up the chimney. The negative draft, however, will force the air into the basement if any leaks exist. Negative chimney draft has been observed at least 25 times the past two summers, yet the fire required for operating the test unit at 5 per cent of its rating has never been adversely affected because of precautions taken to make it airtight.

By positive airtightness is meant the equivalent of watertightness under hydrostatic test. Clearances around shaker handles, cracks in ashpit and draft doors, loose joints between sections, etc., are not permissible for good control. Because of the small flue-gas quantities involved, it is surprising to what extent seemingly small leaks above or below the fuel bed affect the efficiency of domestic heating units.

FIG. 3 HOME HEATED BY AIR CONDITIONER
(Maximum heat loss is 75,000 Btu per hr, and the conditioner supplies 100,000 Btu per hr.)

COMBUSTION OF FUEL AT VERY LOW RATES

Five times during the early summer of 1934, room heating and cooling were alternated because of climatic conditions. A temperature of 103 F on June 1 was followed by 58 F cold winds on June 16. It seems that the ultimate use of solid fuels for domestic heating must consider maintenance of a continuous fire to eliminate frequent starting during spring and fall, with the capacity of the unit varying from 100 per cent to zero per cent without loss of the fire.

Combustion of fuel at 5 per cent boiler rating is somewhat similar to spontaneous combustion of coal in a coal pile. No evidence of combustion is visible above or below the fuel bed, and the so-called furnace temperature is less than 200 F (see Table 4). Slow insertion of a temperature-recording element into the fuel bed shows gradually increasing temperature until incandescent coals are reached in the center. On one occasion, 1300 F was measured at the center of the fuel bed. The low thermal conductivity of lump coal assists greatly in its combustion at low rates. Attempts to determine the minimum rate of combustion in this particular equipment have not yet shown the bottom rate. With the exception of two stops for reasons other than combustion failure, the fire was continuous for a year. On several days its output did not exceed 1000 to 2000 Btu per hr (1 to 2 per cent rating), yet it accelerated rapidly when desired.

Since draft requirements normally vary with the square of rating, a draft of only a few thousandths of an inch is necessary to maintain low rating, which the furnace itself readily provides. Thus if 0.10 in. of draft is required at 100 per cent rating, 5 per cent rating requires only about 0.00025 in. of draft. Since a 2-ft column of 200 F air provides about 25 times this draft, airtightness of the ashpit is necessary to prevent the rating from going higher than 5 per cent. This explains why most homes are overheated in moderate weather, and why summer fires with solid fuels almost invariably require special control.

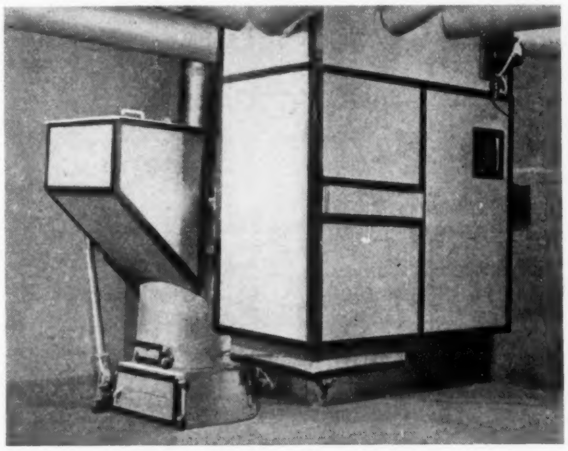


FIG. 2 AIR-CONDITIONER PHOTOGRAPH
(Hopper feed of an unusually small, standard hot-water boiler provided the fuel-burning experiences treated herein.)

Radiation losses from the boiler and service-water storage tank furnish sufficient load to maintain a continuous fire when no warmed water is used. Storage of warm water eliminates the need of instant response from the fire at high rates. Ability to stop all air flow through the fuel bed after periods of acceleration is found to be positively necessary in order to prevent over-runs.

Efficiency at low ratings does not necessarily suffer from lack of fuel temperature. Table 4 shows as high as 10 per cent CO_2 at 8 per cent rating, and a boiler outlet temperature of 160 F. An average of about 4 per cent CO_2 was observed during the summer. A bushel of refuse collected during a period of summer operation showed 40 per cent combustible in the ash. This experimental evidence indicates that air flow must be greatest through hottest portions of the fuel bed, and that a large excess of oxygen is not necessary for combustion at relatively low temperatures.

HOPPER PERFORMANCE

The usual difficulty of hopper supply methods, namely, burning-back into the hopper, never occurred. The use of non-caking fuels (coke and anthracite coal), airtightness of the ashpit, fire pot, and hopper, and the adoption of a plan for ventilating the hopper with flue gas were probably responsible for combustion staying some distance from the hopper connection. The recirculation of the flue gas through the hopper prevented condensation of water in the hopper which, before the adoption of this recirculation plan, caused caking of the fuel at the hopper entrance, resulting in a stoppage of fuel flow and loss of the fire.

Although the small-sized fuel that was selected clinkers very easily when burned in warm-air furnaces, no trouble from this source was experienced in the test installation because the coke was supplied uniformly to the fire as needed, a relatively thin fuel bed was maintained, and excessive rates of combustion were prevented. Thus, the hopper method of stoking permits the use of small-sized fuels, which are ordinarily less expensive.

FURNACE ATTENDANCE—SMOKE PIPE PERFORMANCE

It was found during the tests that it was necessary to fill the fuel hopper and shake the ashes but once daily in order to maintain uniform room temperatures during average heating-season days. During zero weather, two visits were necessary when coke was used because of insufficient hopper capacity.

During summer operation, shaking was normally practiced every two or three days and the hopper was filled once weekly. However, the frequency of attending the furnace can be lessened considerably if special attention is given to the completeness of the shaking.

A water make-up valve in the expansion tank eliminates danger of boiler injury due to accidental low water. The boiler can be, and has, inadvertently changed to a steam boiler without trouble resulting.

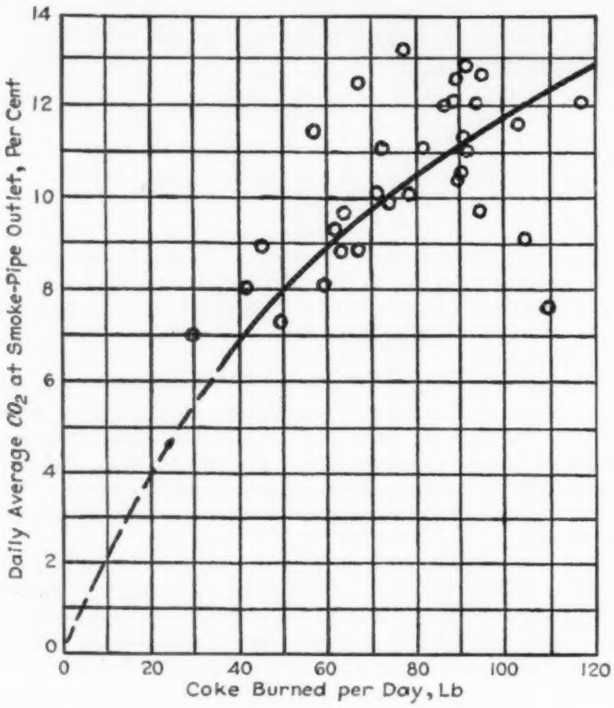


FIG. 4 10 PER CENT CO_2 AT THE SMOKE-PIPE OUTLET, WHEN FLUE-GAS TEMPERATURE AVERAGES 160 F, REPRESENTS LESS THAN 5 PER CENT DRY FLUE-GAS LOSSES

The smoke pipe is in effect an air heater, and its performance, because of airtightness and low excess air used for combustion, was comparable to that of modern air heaters serving large boilers. Basement heating was needed because of low radiation losses from the small boiler and the insulated air casing. Compared with typical full-size air heaters, the smoke pipe has proportionately the same area per pound of coal at peak ratings. It has one-third the unit heat-transfer rate (because of absence of fans and resulting low gas and air velocities) and three times as great a mean temperature difference, which made its performance about identical with large air heaters. It lowered the temperature of the boiler outlet flue gases from 667 F to 361 F, a drop of 306 F, performance practically as good as any modern air heater. The performance at the various ratings is as follows:

Approximate capacity, per cent	25	50	100
Temperature drop of flue gases, F	192	249	306
Heat-transfer rate, Btu per hr per sq ft per deg F	0.4	0.7	1.1

TABLE 2 SPECIAL TESTS

Capacity, approximate, per cent	25	50	100
General			
Date, 1933	March 26	March 19	April 9
Duration, hours	8	10	10
Outdoor temperature, F	45	26	40
Temperature, F			
Air heated			
Radiator outlet	98	136	168
Radiator inlet	69	72	72
Radiator rise	29	64	96
Flue gases			
Boiler outlet	320	451	667
Smoke-pipe outlet	128	202	361
Boiler water			
Radiator inlet, avg	142	172	206
Radiator outlet, avg	...	...	177
Service-water heater			
Inlet	...	...	206
Outlet	...	...	189
Service water			
Outlet	...	...	125
Inlet	...	...	108
Basement temperature	66	64	...
Flue-gas analyses, per cent			
CO_2	12.5	12.6	13.7
O_2	8.25	...	6.6
CO	0.15	...	0.3
Total quantities, lb			
Humidity water evaporated	...	...	26
Fuel used	21.5	49	109
Refuse			
Per cent combustible	7.33	6.2	5.25
Air flow			
Cfm above radiator	935	935	1175
Cfm at registers	...	...	1291
Cfm avg	...	...	1233
Fuel			
Total fired, lb	21.5	49	109
Lb per hour	2.69	4.9	10.9
Analyses			
Fixed carbon, per cent	...	...	92.03
Ash, per cent	...	...	6.7
Moisture, per cent	15	18.0	8.0
Btu per lb, as fired	10600	11000	11900
Btu per hr fired	28500	54000	128500
Heat output, Btu per hr			
By radiators	27800	61500	102000
At registers	...	...	101000
To heat service water	1000	1500	2000
To evaporate humidity water	1000	1500	2700
Total, at radiator	29800	64500	106700
Total, at registers	...	...	105700
Heat balance and efficiency data			
Boiler only, per cent			
Losses, due to			
Moisture in fuel	1.1	2.1	0.93
Hydrogen (1 per cent)	1.0	1.04	0.99
Dry flue gas	10.2	15.50	18.5
Moisture in air	0.15	0.25	0.35
CO	1.0	1.5	2.1
Combustible in refuse	0.5	0.5	0.41
Radiation	3.1	1.9	1.5
Total losses	17.1	22.8	24.8
Calculated efficiency, per cent	82.9	77.2	75.2
Boiler and smoke pipe			
Losses, due to			
Moisture in fuel	1.0	1.9	0.80
Hydrogen (1 per cent)	0.9	0.95	0.85
Dry flue gas	2.4	5.4	9.1
Moisture in air	0.05	0.12	0.17
CO	1.0	1.5	2.1
Combustible in refuse	0.5	0.5	0.41
Radiation (useful)	0	0	0
Total losses	6.0	10.4	13.4
Calculated efficiency, per cent	94.0	89.6	86.6

Experience indicates that airtightness of the smoke pipe has incidental merit in that it reduces smoke-pipe corrosion. The reduction of such corrosion is effected by elevating the temperature of the smoke-pipe metal by airtightness, thus reducing the deposition of highly corrosive hygroscopic sulphur compounds which normally are deposited on relatively cool surfaces such as would exist if air were bled into the smoke-pipe inlet for checking combustion. Some corrosion was, of course, experienced, part of which was probably due to the maintenance of a summer fire. It might be appropriate to mention at this point that using basement air for checking combustion may cost a half ton of fuel per season in a typical residence.

USE OF OVERFIRE AIR

During the tests it was found that the opening of small ports above the fire increased flue-gas losses. Considerable experience proves that with coke and anthracite fuels, higher efficiency is averaged without any attempt to reduce CO losses by overfire air.

Reduction of CO_2 to CO occurred after $1^1/_2$ hours' operation during the 100 per cent rating test, causing 2.6 per cent CO until overfire air was admitted. Since the unit is seldom operated at 100 per cent rating for any considerable length of time, the seasonal loss from this source is slight.

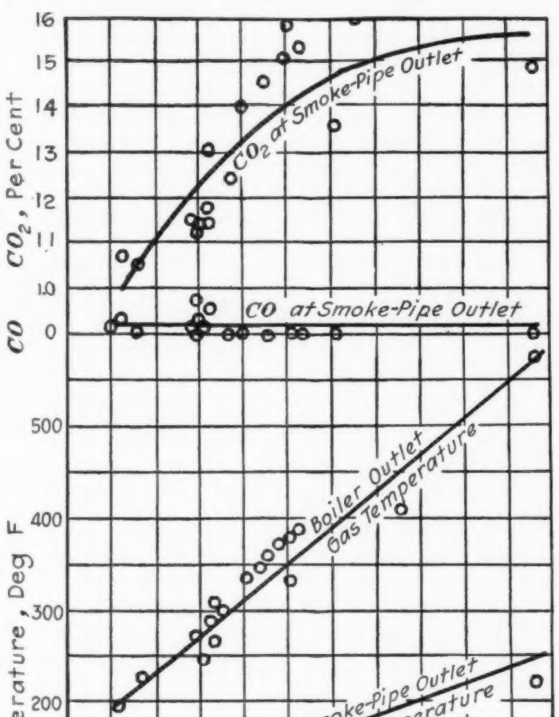


FIG. 5 VARIABLE RATING TEST, CLOSELY TYPICAL OF AVERAGE OPERATION

(At least 90 per cent efficiency was averaged, if radiation losses are credited. Rating varied widely to regulate constant room temperature, and averaged 25 per cent.)

The greatest urge for overfire air injection consists of using it as a means to reduce low-pressure explosions of CO-air mixtures which occur when appreciable quantities of coke or anthracite are placed on an incandescent fuel bed of a hand-

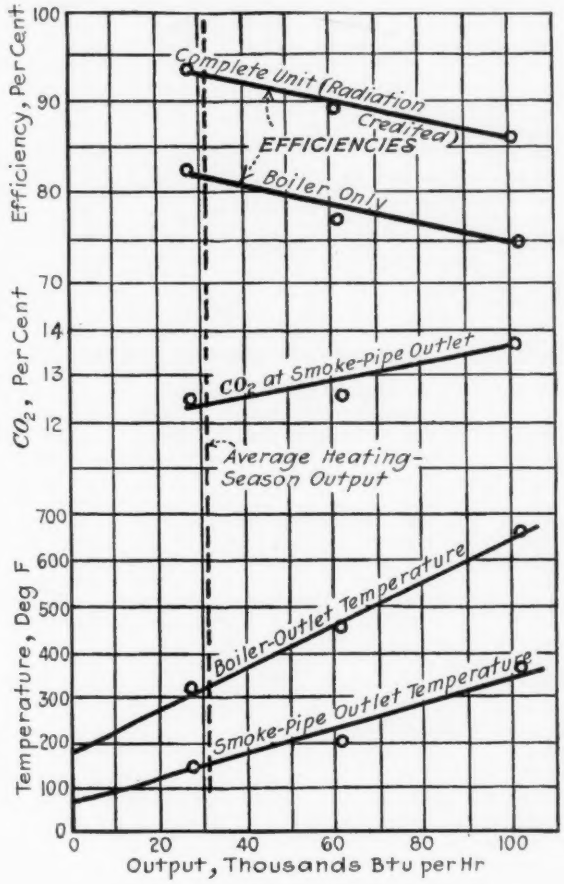


FIG. 6 RESULTS OF SPECIAL TESTS

(At average heating-season output, note that efficiency (crediting radiation) is 90 per cent, CO_2 above 10 per cent, and flue-gas temperatures about 300 F and 150 F.)

fired unit, or when a hopper-stokered unit is shaken vigorously with a low fire existing. Such explosions sometimes extend into the chimney. It was found during the tests that anthracite coal seemed more susceptible to this trouble than 5 per cent volatile coke.

PREVENTION OF BOILER-WATER CORROSION

It was found that the boiler water in the unit contained but 1 per cent as much dissolved oxygen as tap water, i.e., 0.05 cc per liter for boiler water as compared with 6.0 cc per liter for tap water. This low oxygen concentration, resulting in crystal-clear boiler water, was obtained by using a float-covered expansion tank and fairly frequent heating of the boiler water to nearly its boiling point. The presence of slight protective coatings and low oxygen concentration limited the corrosion rate and permitted the use of highly efficient heat-transmitting tubes in the air-heating unit without danger of their becoming clogged with rust particles or being subjected to corrosion.

Central-station practice recognizes the need of maintaining low oxygen content of boiler feedwater. Small steam boilers operating with a boiler-water temperature of 170 F during

TABLE 3 COKE AND ASH ACCOUNTING

Coke Delivery No.	1	2	3
Date first used	Feb. 21	Mar. 16	Apr. 8
Coke, as fired, lb	2417	2345	1925
Moisture, per cent			
As received	.....	21.5	10.0
As fired	.....	13.0	5.0
Average	17.0[a]	17.0	7.5
Coke, dry, lb	2000	1950	1780
Ash			
By analysis, dry, per cent	9.5	9.5[a]	6.7
Refuse			
Lb, dry	202	155	121.5
Per cent combustible, dry	8.2	6.2	7.4
Ash only, lb	185	145	113
Ash only, per cent of coke	9.25	7.4	6.3
Difference, per cent ash by analysis versus per cent ash by weight	+0.25	+2.1	+0.4

[a] Assumed.

TABLE 4 DATA OF OPERATION AT LOW RATINGS

(*Test of June 14, 1934*)

Time, min	Furnace temp, F	CO_2 at smoke-pipe outlet	Boiler water temp, F	Draft, in. of water
1	233	..	...	0.010
2	233	..	...	0.009
5	190	7.5	...	...
8	174	8.3	155	0.007
12	174	9.3	155	0.014
16	190	10.7	156	0.009
19	243	11.0	157	0.009
24	229	11.6	160	0.006
27	190	11.2	163	0.005
30	162	10.8	165	0.006
35	...	7.7	168	0.006

Approximate output, Btu per hr	7800
Fuel	Anthracite pea coal
Temperature in center of fire, F	1300
Two months' operation	
Fuel consumed, June 30 to August 30, lb coke, 21 per cent moisture	654
Average Btu per hr input	4600
Average combustion rate, lb per sq ft grate area per hr	0.26
Cost per month, at $8.50 for 2300 lb	$1.23

summer for service-water heating are particularly subjected to corrosion. Their large water surface permits saturation of the boiler water with about 50 per cent as much oxygen as in tap water. As in other chemical reactions, it is probable that a temperature increase of 20 F doubles corrosion rate, causing a corrosion rate 16 times as rapid as at 70 F atmospheric conditions.

WATER AS A HEAT-TRANSFER MEDIUM

Maintenance of all metal temperatures within a few degrees of 212 F insures freedom from repair and from the need of constant prevention of air leaks. Metal temperatures over 1000 F, as are attendant with direct transfer of heat from burning fuel to the air to be heated, cause large relative thermal expansions, and oxidation and growth of the metal are imminent.

The unit being discussed uses water under a static head of only a few feet in a boiler directly open to the atmosphere at all times through an expansion tank. Thus, the so-called boiler is essentially an open vessel in which steam pressures can never occur. This type of boiler was adopted because it permitted economical construction and because water circulates readily through any accompanying heat-absorbing surface, especially at high ratings, when a few steam bubbles form temporarily within the boiler water. Very little water is used in the system, permitting rapid assumption of high outputs as in large modern boilers. In this respect, the unit utilizes the distinct trend of central-station boilers. This small installation was brought from cold to full output in 23 minutes on one occasion when a fire was started.

The use of water as a heat-transfer medium permits the use of extremely efficient automotive-type radiators for air heating. Compared with the usual cast-iron radiators used in domestic heating, they are almost phenomenal as regards size, simplicity of connections, small water-storage capacity, space occupied, weight, and cost. The 0.005-in. thin copper fins transfer heat on both sides at the high rate of 8.5 Btu per hr per sq ft per deg F (when the fan operates). Usual cast-iron radiators, at least $^1/_8$ in. thick, surrender heat on only one side at the relatively low unit rate of 1.5 Btu per hr per sq ft per deg F. In addition, the automobile-type radiator is used readily for room cooling.

SOLID FUELS FOR DOMESTIC HEATING

Solid fuels, being conducive to high combustion efficiencies, have for this reason an advantage over liquid and gaseous fuels. As stated previously, the fuel bed acts as an oxygen filter, regulating the excess air by an inherent capacity to absorb oxygen at a definite, favorable rate. Thus, the air supply to the fuel bed need not be regulated accurately to prevent a serious dearth of oxygen or a large excess, either of which may occur when burning fluid fuels.

Attention to important details in the design of solid-fuel-burning equipment permits new high standards of efficiency and greater freedom from attendance. Average domestic heating requires low total costs, freedom from mental attention, and uniform room temperatures. The average present-day heating plant for burning solid fuels is not ideal in these respects.

It is believed that freedom from mental rather than from manual attention is most desired of domestic heating plants. Filling of a stoker hopper regularly, once daily, may not be regretted if the attendant can be relieved of being an expert and attentive fireman throughout the remainder of the day and night. Solid fuels can certainly regulate room temperatures within a split-degree Fahrenheit if properly controlled.

If stoking equipment can relieve the attendant of thinking of the condition of his fire, of anticipating heating demands, of staying home at times simply to nurse the fire, and of fearing that it may become extinguished if checked too much, then it can make the burning of solid fuels greatly more acceptable. With clean fuel and dustless handling of ashes, serving of the fire then becomes no more than acceptable physical exercise. In some cases, fuel can be delivered directly into the stoker hopper.

SAFETY WITH SOLID FUELS

When life is endangered, importance of safety aspects cannot be overestimated. Where improper performance of heating equipment endangers sleeping occupants, fatalities often result.

Separation of the fuel-combustion and the air-heating processes in separate casings, each of which is consistently airtight, appears to be a fundamental step toward reducing the hazards of gas poisoning. A second necessary step is the need for regulating the fire only by the ashpit door, using a closed passage to the chimney and thereby eliminating an opening whereby gases can escape into the basement. The smoke pipe should be gastight and should remain so without frequent

TABLE 5 RÉSUMÉ OF DATA FROM REPORT OF CHICAGO DEPARTMENT OF SMOKE ABATEMENT

Total solid fuel received in Chicago, 1933:

	Tons	Per cent
Bituminous coal	14175000	67.0
Semi-bituminous coal	5194000	24.5
Coke	1518000	7.0
Anthracite coal	350000	1.5
Total	21237000	100.0

Consumption of fuel by classes, tons (per cent in parentheses):

	Coal	Coke	Oil[a]
Domestic (up to four apartments)	3794000 (78)	601000 (12)	480000 (10)
Large apartment and commercial buildings	5550000 (98)	....	110000 (2)
Power plants	7261000 (97)	....	230000 (3)
Railroads	1103000 (100)	....	2600 (..)
Metallurgical and special processes	517180 (29)	914000 (51)	350000 (20)
Others	1372000 (98)	....	30000 (2)

Responsibility for Chicago's smoke:

Class	Solid fuel burned, per cent of total	Smoke responsibility, per cent of total
Domestic	20.8	20.4
Apartments and large heating units	26.3	43.0
Power plants	34.4	25.4
Central district	5.9	5.1
Metallurgical and special processes	6.8	2.4
Railroad locomotives	5.2	2.8
Boats	0.6	0.9

[a] Equivalent tons.

replacements. A self-closing "puff" (low-pressure CO-air explosion) door, and tightly fitted firing and ashpit doors, will cope with infrequent gas explosions without creating a real hazard. The desirability of these precautions should not suggest that solid fuels are less safe than others for domestic service.

Improper proportioning of solid fuel and air can have no serious consequences, outside of infrequent low-pressure CO-air explosions of limited energy. The use of solid fuels eliminates dangers encountered with the use of fluid fuels in the event of supply-line breakage.

Several recently reported catastrophic turbine-oil fires in central stations prove that seemingly inert oil offers a serious hazard when near heated surfaces. On the other hand, solid fuels appear almost incombustible to many householders, who often experience very annoying trouble when starting furnace fires.

SMOKE-ABATEMENT ASPECTS OF SOLID FUELS

The considerably higher efficiencies inherent in burning solid fuels with proper equipment should do much to obtain adoption of such equipment with resulting important smoke-abatement aspects. The figures in Table 5 from the recent report of the Chicago Department of Smoke Abatement show the relative magnitude of smokeless and smoking fuels used in Chicago, and for perhaps the first time evaluate the relative amount of smoke emanating from major sources of its generation.

Domestic users are responsible for 20 per cent of Chicago's smoke. Since making 300,000 expert firemen for the 300,000 Chicago residences, or inducing the use of non-smoking fuels in every home, are both improbable, attention to development of desirable equipment that will render present equipment obviously obsolete appears one solution of the domestic smoke problem.

TABLE 6 CAPACITY AND DESIGN DATA OF EQUIPMENT

Boiler: Cast iron, round sectional, 280 sq ft 8-hr rating, 825 sq ft rated capacity, 18 in. diam, 1.76 sq ft grate. 48 in. high, 22 in. outside diam. Approximately 18.75 sq ft heating surface. Water capacity 90 lb. Total weight, 700 lb.

Covering: $^3/_4$ in. plastic cement having 0.8 Btu per hr per sq ft per deg F per 1 in. conductivity, painted aluminum bronze.

Grates: $^1/_8$-in. opening, three in number.

Smoke pipe: 9 in. diam, 10 ft long, airtight 24-gage sheet metal, painted black.

Radiator: $20^1/_2$ in. × $23^3/_8$ in. automotive-type, fin and tube, 167 sq ft.

Fins: 6 per in. $3^5/_8$ in. × $23^1/_2$ in., 0.005 in. thick, 140 total.

Tubes: $^1/_8$ in. × $^3/_4$ in., 0.008 in. thick. $^7/_{16}$ in. spacing, 4 rows deep, 2 per pass, 184 total tubes.

Water Boxes: 18 gage brass. Inlet water box has internal baffle. 2-in. standard pipe connections.

2.25 sq ft air flow area, 5.9 sq in. water-flow area per pass. 26 per cent direct surface, 74 per cent finned surface.

Motor: $^1/_{20}$-horsepower, 1140 rpm, 110 volts, unit-heater type. Totally enclosed, wick oiling, 57 per cent efficiency, 55 per cent power factor, 1.07 amps, 65 watts at full load, rubber mounting.

Fan: 4 blade 16-in. propeller type.

Filter: Four 20 in. × 20 in. × 2 in. oiled glass-wool units arranged in parallel.

Humidity pan: 6 in. × 20 in. × 20 in., 12-gage sheet pan, two 16-in. lengths of 1-in. pipe and return bend for heating coil.

Leader pipes: 2.5 sq ft flow area, composed of 34 ft of 8-in. pipe and 15 ft of 10-in. pipe.

Cold-air return pipes: 2.35 sq ft air-flow area, composed of 21 ft of 12-in. pipe.

Fuel hopper: 4.6 cu ft, 125 lb normal charge.

Airflow casing: 2 ft × 4 ft × 5 ft high outside. Wall-board on 2-in. × 2-in. pine frame. Painted aluminum bronze. Lined with $^3/_8$-in. felt.

Thermostat: Spring motor. 50 operations per winding. Operates on bell transformer.

TABLE 7 ANNUAL OPERATING AND INVESTMENT COSTS

	Warm-air furnace	Air-conditioning unit
Initial cost, installed	$200.00	$250.00
Annual fixed charges, 12 per cent	24.00	30.00
Operating Costs		
Heating:		
Tons of coke used	10	8.5
Cost of coke per ton	$ 8.50	$ 8.50
Total fuel cost	85.00	72.25
Cost of electricity, 133 kwhr at 3¢	....	4.00
Total cost	85.00	76.25
Cooling:		
Cost of water	....	4.85
Cost of electricity	....	1.17
Total cost	....	6.02
Service-water heating during summer (four months):		
Cost of gas, $0.75 per thousand cu ft	6.00	....
Cost of coke	....	4.00
Maintenance:		
Annual average	15.00	5.00
Total annual operating cost and fixed charges	130.00	121.27

SUMMARY

Experiences are cited showing that present methods of burning solid fuels in residences can be bettered appreciably by application of central-station practice. With non-caking fuels, efficiency can be elevated to that of large power boilers, and attention can be reduced to simply manual attendance once daily. Fires can be maintained at very low output to eliminate frequent starting and to afford instant heat when needed. The higher efficiency and less attention when burning fuel with improved apparatus should do much toward smoke abatement.

ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

Hydraulic Analogies for Steam-Turbine Stages

THE author discusses first the dissimilarities in the methods of investigating steam and water turbines. While the latter can be developed to a large extent from models, the former do not permit of model tests from which machines of commercial size can be directly designed.

The purpose of the present investigation is to develop theoretical bases for the performance of model tests on steam turbines and similar machinery. An attempt is made to express laws of similarity for compressible fluids in a form similar to that which has proved so valuable to the engineer in designing hydraulic turbines. The formulas developed in this way are applicable not only to steam turbines but also to such machinery as gas turbines, centrifugal blowers, and centrifugal compressors.

The most important applications of the laws of similarity in hydraulic turbines deal with the specific speeds (usually denoted by n_s). For each value of n_s there is a type of wheel which may be considered the most desirable. Of the many types of wheels proposed, only a few are used today, because these latter types are superior to all others for a similar n_s. In the present investigation an attempt is made to transfer to the case of steam turbine the concept of specific speed. The difficulty lies in the fact that for a given case (state of steam, output, and revolutions) quite a number of constructions are available, all of which are different but which are approximately equivalent in the matter of performance. This is due to the use of multiple stages in steam turbines, which make it possible to divide the available head in many different ways. A particular arrangement of velocity and shape of blade is possible only for single-stage machines, and this makes it necessary to confine considerations of similarity to a single stage, if only in order to obtain results of value.

There is another reason why investigations are confined to a single stage, and that is the methods of testing. That is, in order to investigate thoroughly the effect of individual processes on the performance of the machine it is necessary to deal with the single-stage machine only. In the multi-stage steam turbine the various stages do not operate under the same conditions of state. The result is that so many independent processes are there tangled together that the separation of their effects becomes impossible. The author therefore confines himself to the consideration of a single turbine stage, and from that proceeds to the investigation of conditions producing hydraulically similar kinds of flow.

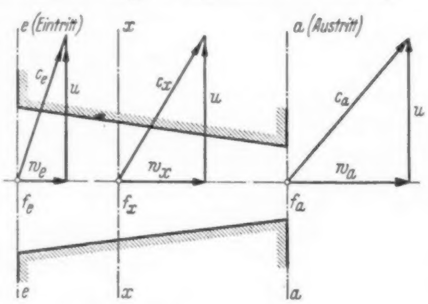


FIG. 1 VELOCITIES IN RESTRICTED BLADE PASSAGES HAVING A STRAIGHT CENTER LINE
(*Eintritt*, inlet; *Austritt*, exit.)

In carrying out tests on models comparable results have been obtained only where the hydraulic similarity has been maintained and this requires the following conditions to be satisfied: (1) Geometric similarity of the dimensions of the turbine and model; (2) geometric similarity of all velocity triangles; and (3) equality of the Reynolds coefficient. The third requirement cannot be satisfied, as is shown elsewhere in the article.

Fig. 1 shows a blade passage with a straight center line. The passage is supposed to move upward with the peripheral velocity u (in meters per second). This passage, contracting in the direction of flow, provides a path for the flow of a compressible fluid. The flow must therefore be associated with a loss of pressure in the fluid, and the relative velocity w (in meters per second) between the fluid and the passage must increase. The velocity triangles at various cross-sections e, x, and a of the passage, therefore, are neither congruent nor geometrically similar. If we denote by G (in kilograms per second) the weight of the fluid flowing per second, by v (cubic meters per kilogram) the unit volume of the flowing fluid, by f (square meters) the cross-section of the passage, and select the subscripts in accordance with Fig. 1, the following equations of continuity are obtained

$$w_e = \frac{Gv_e}{f_e}; \quad w_x = \frac{Gv_x}{f_x}; \quad w_a = \frac{Gv_a}{f_a} \quad ..[1]$$

The author considers next the flow as already discussed in a turbine as well as in a model. In what follows, all the magnitudes which refer to the turbine have the subscript t and those referring to the model m. In order that hydraulic similarity may be maintained, it is necessary that there shall be geometric similarity of the passages, this means that

$$(f_e : f_x : f_a)_t = (f_e : f_x : f_a)_m \ldots [2]$$

The geometric similarity of corresponding velocity triangles must likewise be expressed by

$$(w_e : w_x : w_a)_t = (w_e : w_x : w_a)_m . [3]$$

or after inserting the values from Equation [1]

$$\left(\frac{Gv_e}{f_e} : \frac{Gv_x}{f_x} : \frac{Gv_a}{f_a}\right)_t = \left(\frac{Gv_e}{f_e} : \frac{Gv_x}{f_x} : \frac{Gv_a}{f_x}\right)_m \quad \ldots\ldots [3a]$$

and with this, Equation [2] gives

$$(v_e : v_x : v_a)_t = (v_e : v_x : v_a)_m . . [4]$$

which means that in a model test with compressible fluids the relations between the unit volumes at corresponding points of the passages of the turbine and model must be equal to each other.

The loss of pressure in the fluid occurs in accordance with the polytropic law

$$Pv^m = \text{constant} \ldots\ldots\ldots [5]$$

The external work of expansion from e to x is

$$L = P_e v_e \frac{m}{m-1}\left[1 - \left(\frac{v_e}{v_x}\right)^{m-1}\right]$$

[m-kg per kg]......[6]

This work serves to increase the velocity of flow and cover the flow losses. It is therefore

$$L = \frac{w^2_x - w^2_e}{2g} + \zeta\frac{w^2_e}{2g} = \frac{w^2_x - (1-\zeta)w^2_e}{2g} \quad \ldots\ldots[7]$$

where ζ is the "coefficient of loss."

This is divided by $w^2_e/2g$ which gives

$$L : \frac{w^2_e}{2g} = \frac{w^2_x}{w^2_e} - (1-\zeta) \quad \ldots.[8]$$

For conditions of hydraulic similarity the coefficient of loss ζ is the same in both cases. According to Equation [3] it is equal to w_z/w_e. Hence

$$\left[\frac{w^2_x}{w^2_e} - (1-\zeta)\right]_t = \left[\frac{w^2_x}{w^2_e} - (1-\zeta)\right]_m \quad \ldots\ldots[9]$$

The left side of Equation [8] must satisfy the same condition

$$\left.\begin{aligned} &\left[L : \frac{w^2_e}{2g}\right]_t = \left[L : \frac{w^2_e}{2g}\right]_m \\ &\text{or} \\ &\left[\frac{P_e v_e}{w^2_e}\frac{2gm}{m-1}\left(1-\left(\frac{v_e}{v_x}\right)^{m-1}\right)\right]_t \\ &= \left[\frac{P_e v_e}{w^2_e}\frac{2gm}{m-1}\left(1-\left(\frac{v_e}{v_x}\right)^{m-1}\right)\right]_m \end{aligned}\right\} \quad \ldots\ldots[10]$$

This equation holds for every point of the blade passage, that is, for every value of v_e/v_x. Mathematically speaking we have here an identity, from which it follows that in Equation [10] both members of each side are equal to each other. This gives the first condition for hydraulic similarity in the case of model tests

$$\left(\frac{P_e v_e}{w^2_e}\frac{m}{m-1}\right)_t = \left(\frac{P_e v_e}{w^2_e}\frac{m}{m-1}\right)_m \quad \ldots[11]$$

This condition is of fundamental importance in carrying out model tests with compressible fluids. In the case of a turbine, P_e, v_e, w_e, and m are given, which determines the value of the left side of Equation [11].

It follows from this that in a model w^2_e must be proportional to $P_e v_e m/(m-1)$. Since all the velocities are given when w_e is given because of geometrical similarity of velocity triangles (and hence u also is given), all the velocities depend in the same manner on this magnitude. The real reason for it is the fact that according to Equation [6] the work of expansion L, and hence the fall per stage for a given ratio of volume, is proportional to $P_e v_e m/(m-1)$. From this it follows that in model tests with compressible fluids, it is not permissible to select freely the fall per stage in the model as is done in water turbines, as in the former case this depends on the initial state of the steam used in the test, the ratio of volumes, and the exponent of expansion.

The second condition which can be derived from Equation [10] is

$$\left(\frac{v_e}{v_x}\right)^{m_t - 1} = \left(\frac{v_e}{v_x}\right)^{m_m - 1} \quad \ldots[12]$$

This condition for any value whatsoever of v_e/v_x can be satisfied only when

$$m_t = m_m \quad \ldots\ldots\ldots\ldots[13]$$

that is, there is hydraulic similarity only when the exponents of expansion in the turbine and model are equally great. This statement is of particular importance when the tests on models are carried out with a fluid different from that with which the turbine operates. In practice this happens in model tests of steam turbines when the state of the steam used in the model differs from that of the steam used in the turbine. The forementioned condition is not satisfied, as the exponent of expansion depends on the state of the steam and the stage efficiency.

The author denotes by the term "hydraulically similar fluids," fluids with the same coefficients of expansion. Where the fluids have variable coefficients of expansion, the hydraulically similar fluids may be defined, as follows:

Two fluids are hydraulically similar when their *T-s* or *i-s* diagrams are geometrically similar or when their exponents of expansion are equal to each other. With this definition the requirement may be stated, as follows:

In the case of model tests with compressible fluids hydraulically similar states of operation can be attained only when hydraulically similar fluids operate the turbine and the model. It is shown elsewhere, however, that the deviations from hydraulic similarity where hydraulically dissimilar fluids are used are comparatively small.

SPEED OF STEAM-TURBINE STAGES

The specific rpm or speed n_s of a water turbine is the rpm of a turbine hydraulically similar to the given machine and delivering one horsepower at a head of one meter. The following formula is given for the specific speed

$$n_s = \frac{n}{H}\sqrt{\frac{N}{\sqrt{H}}} = \sqrt{\frac{\gamma}{75}}\, n\, \frac{\sqrt{V_W \eta}}{\sqrt[4]{H^3}} \quad \ldots[14]$$

where η is the efficiency, n the revolutions per minute, H the head in meters, N the output in horsepower, V_W the volume of water in cu m per sec, all for the given turbine, and γ the weight of unit of water in units of 1000 kg per cu m.

The definition of specific speed in Equation [14] has two disadvantages. In the first place it contains an expression for output in horsepower, while today the usual way to measure output is in kilowatts. Next, it does not contain the dimension for the number of revolutions, nor is it dimensionless.

Dimensionless coefficients, however, have the advantage of being essentially independent of the dimensions of their individual factors. Notwithstanding proposals to have it changed, the concept of speed is still retained in the old form and therefore has to be applied to the case of steam turbines as it stands.

The value of n_s depends on the shape of the blading and on the conditions of operation. Usually n_s is given only for the best efficiencies and indicates the value which does not depend on the state of operation.

There are two difficulties in the way of transferring this concept to the steam turbine. In the first place, the weight per unit of steam is not the same as that for water, and, second, this weight is not constant. If we drive the water turbine with different fluids, such as ether and mercury, while the state of operation remains hydraulically similar, different values for n_s for the turbine will be obtained according to Equation [14], because γ is no longer equal to 1000 kg per cu m.

However, it is necessary to insist that each kind of blading be given only one value of n_s for a given state of operation. This can be attained by adding to the definition of n_s the requirement that the turbine used as a basis of comparison be driven by water. The variability of γ in the case of compressible fluids is taken care of by expanding the conception of speed as follows:

The speed of a flow machine is the number of revolutions of a hydraulically similar machine which delivers one horsepower for a fall of one meter when operated with a hydraulically similar fluid which at the exit from the rotor has a specific weight γ = 1000 kg per cu m.

The formula for computing n_s is found in the following way: Let it be assumed that a turbine stage operates on steam of volume V_D cu m per sec and specific weight γ_D in kg per cu m at the exit from the rotor. The adiabatic drop per stage is h in kcal per kg, or $H = 427h$ (in m). The output per stage is then

$$N_D = \frac{V_D \gamma_D H \eta}{75} \text{ [hp]} \ldots\ldots [14a]$$

Should we drive the same stage with the same head but with a hydraulically similar liquid (water) of specific weight at the exit from the rotor $\gamma W = 1000$ kg per cu m, then the output would be

$$N_W = \frac{V_W\, 1000\, H\eta}{75} = N_D \frac{1000}{\gamma_D} \text{[hp]}. [15]$$

The specific speed per stage is then

$$n_s = \frac{n}{H}\sqrt{\frac{N_W}{\sqrt{H}}} = \frac{n}{H}\sqrt{\frac{N_D}{\sqrt{H}}}\sqrt{\frac{1000}{\gamma_D}} \ldots\ldots [16]$$

It is immaterial whether or not we are dealing here with hydraulically similar fluids having $\gamma = 1000$ kg per cu m. The specific speed is a magnitude obtained by calculation and comparison, from data obtained by tests which may be carried out on any machine operating with any working fluid.

The requirement that γ be equal to 1000 kg per cu m at the exit from the rotor in the case of the fluid serving as a basis of comparison is arbitrary. With the same justification any other cross-section of the passage through which the fluid is flowing could be selected. The exit from the rotor, however, is, in the majority of cases, the point from which calculations of blading are made and is hence characteristic for the shape and size of the machine. Because of this its selection as a starting point for the foregoing calculation is recommended. The formula for n_s given in Equation [16] holds good also for the specific case of the water turbine. Here $\gamma_D = 1000$ kg per cu m = constant, and the square root in the formula is equal to one, while n_s attains the value as given in Equation [14].

The main advantage of the definition of the specific speed in the foregoing form lies in the fact that it makes it possible to take well-known and well-established coefficients from water-turbine design without any change and at the same time to compare numerically with each other the specific speeds of any two machines of any kind.

From this the author proceeds to calculate the specific speeds of various steam-turbine stages and to compare the values as obtained with the specific speed of water turbines. Of particular interest is his discussion of the influence of steam conditions on the results of test on models, and the effect thereon of the Reynolds coefficient. This part may be abstracted in a later issue of MECHANICAL ENGINEERING if space is available. (Prof. E. Sörensen, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 78, no. 48, December 1, 1934, pp. 1403 to 1410 9 figs.)

SHORT ABSTRACTS

AERONAUTICS

Landing of Airplanes

THE progress in airplane design that has been made in recent years has brought with it a certain number of difficulties connected with landing. On the other hand, improved undercarriages and the addition of wheel brakes have done something toward mitigating the difficulties, provided that the earlier technique of landing is modified to suit the new conditions. The mathematical aspect of flattening out and landing has been treated by Glauert, Parts 1 and 2, Reports and Memoranda, Nos. 666 and 667, and by Meredith in Reports and Memoranda, No. 993, while the pilot's point of view has been treated by Hill in Reports and Memoranda, No. 740.

In all these papers complete flattening out has been assumed to be the ideal, and the airplane has been supposed to touch down with zero vertical velocity when perfectly handled. If the incidence of the wings when the airplane is resting on the ground (which will be called the "ground incidence") is equal to the stalling incidence, then a perfect three-point landing will be made at stalling speed and zero rate of descent. This type of landing, which one may call the "classical landing," has been taught by the military and civilian schools for many years, the type of airplane used for training being of not a very efficient type.

Aircraft are now used both in the Royal Air Force and for civil use which are of lower drag than before and which lead the pilot into difficulties when he attempts to land them in the classical manner. In the present discussion an attempt is made to combine flying experience with a simplified theory of the motion in such a way as to assess the importance of various factors in design.

The process of landing is divided into four stages: (1) The initial straight glide; (2) flattening out so that when the path is horizontal the lift is equal to the weight, and wheels and tail skid are close to the ground; (3) floating horizontally with decreasing speed and increasing incidence until either ground incidence or stalling incidence is reached, whichever is the less; and (4) three-point landing, followed by ground run to rest. In an ideal landing (3) does not occur. If the ground incidence exceeds the stalling angle, the landing is inevitably heavy.

The general conclusions reached are that:

(*a*) Ground angle in excess of stalling angle is the main cause of a heavy drop on landing.

(*b*) Tendency to float is mainly an effect of increased aerodynamic efficiency, and is independent of ground incidence. Given the tendency to float, the length of float increases as the ground incidence increases to stalling, if a perfect three-point landing is attempted.

(*c*) Some form of air brake is urgently necessary in order that (1) a greater precision of approach may be obtained, and (2) the least excess of speed which pilots are willing to undertake in the initial glide may be wholly lost in the flattening out.

(*d*) In the absence of air brakes it is best to arrange the ground incidence to correspond to the excess speed at the end of the flattening out, so as to take full advantage of the ground friction. An alternative method, with a robust undercarriage, when the ground incidence is less than stalling incidence, is to perform an incomplete flattening out at stalling, and end by gliding into the ground at a small angle.

In order that the modern aircraft should be landed as easily as the older type, some device is necessary which increases the maximum lift moderately and the drag-lift ratio considerably. A small plate (0.05 chord in depth) fitted normally to the under surface of the wing and about one-tenth of the chord from the trailing edge, described as a Schrenk plate, fulfils these necessary conditions. The Zap flap may go a very great step further, and the question then arises as to how far the pilot can make full use of the properties of the flap in view of the great rate of loss of height in the approach glide, and the difficulty of judging the correct height at which to commence flattening out. The "spoiler" employed as a small projecting plate normal to the upper surface toward the leading edge, and reinforced by powerful wheel

brakes, is about equivalent in its effect on the total landing space to a Schrenk plate of about 0.05 chord in depth without the help of wheel brakes, when the total space is calculated from the clearing of a 100-ft obstacle on the edge of the aerodrome. (R. P. Alston, L. W. Bryant, and I. M. W. Jones, Reports and Memoranda, No. 1598, His Majesty's Stationery Office, London, 1934)

APPLIED MECHANICS

Theory of Bending

THE problem of the elasticity of a straight beam has already been solved by St. Venant, and this solution seems to be still generally accepted. In this method the problem is first solved for the case in which the plane of bending contains one of the principal axes of the moment of inertia of a cross-section and its centroid, and then, for the case in which the plane of bending is in any direction. In the latter case the problem is supposed to be composed of the two cases in which the two principal axes, just stated, are contained by different planes of bending, and the solution of the problem is obtained by combining the solutions of the two cases.

By straight beam, in the present paper, is meant a prismatic part of a beam, which is sufficiently distant from the loaded parts, and the plane of bending is not considered necessarily to contain the axis of the prismatic part, nor to be parallel with a principal axis of the moment of inertia of a cross-section at its centroid.

The solution for the elasticity of a straight beam is given by the stress component in three equations in the original article. The expressions in these equations, except for one magnitude, are of the same form as those usually obtained for the case in which the plane of bending contains one of the principal axes of the moment of inertia of a cross-section at its centroid.

The author next introduces a couple of force in a cross-section and a shearing force and obtains equations which confirm those derived in the usual theory of torsion of a prismatic bar. Shear stresses in straight beams are next derived, as well as expressions for strain and displacement in a straight beam. In general, the elastic problem of a straight beam receiving a turning moment has been solved directly, taking the neutral axis as one of the coordinate axes and without dividing the problem into separate cases. It has also been shown that the theory for a twisted prismatic bar is implied by and can be easily derived from the theory for a straight beam in a general sense, so that the former theory does not need to be derived, as is usual, separately from the latter. (Chidô Sunatani, in Technology Reports of the Tôhoku Imperial University, Sendai, Japan, vol. 11, no. 3, 1934, pp. 267–277, or pp. 1–11, 3 figs.)

FUELS AND FIRING

Cannock System of Oil Distillation From Coal

THE process employed at the Cannock plant calls for serious attention since the unit is of commercial capacity and attractive results are said to have been obtained over a considerable period of time. The process may be described as one of destructive distillation.

The coal is treated in a finely divided or pulverized form and is charged in admixture with about 50 per cent of heavy oil resulting from the carbonization of previous charges. The heavy suspension of coal and oil resulting from the mixture of the two is charged into the retort continuously.

The retort is essentially a rotating steel cylinder without any refractory lining, fired externally by oil or gas burners. The retorts, of which there are two at the Cannock plant, are each about 50 ft long by 5 ft in diameter, inclined about 1 ft in their length.

The charge is fed in centrally at the higher end and forced on to the hot plates of the revolving cylinder, causing an immediate evolution of the lighter products of distillation. The gas evolved by the carbonization of the charge is used for heating the retort, no surplus for disposal outside of the plant being available. The volatile products are drawn off through condensers to an ordinary topping plant where the motor spirit is condensed and taken off for its final treatment by washing. The non-condensable gases go to the retort burners, and the residual heavy oil is used for mixing with coal for subsequent charges. In the present practice at Cannock all of the heavy oil is not returned, as each ton of the mixture retorted includes about 18 gal of creosote from high-temperature carbonization.

Light spirit may be considered as one of the primary products. About 15 gal of motor spirit per ton of mixture is said to be produced on an average, but there is evidence that this could be increased by better condensation from the gases. There is no appreciable yield of tar in condensing the products.

The other main product is smokeless fuel, of which approximately 15 cwt per ton of coal in the mixture charged is obtained. This ranges in size from fines to large separate lumps and is rather friable, though strong enough to be handled without producing excessive fines. The larger sizes are suitable as a smokeless fuel for domestic grates as they ignite easily, having a volatile content of about 10 per cent.

The remainder of the article describes tests made by Dr. C. H. Lander together with a report from a user of Cannock made semi-coke.

The abstract is taken from an article in the November, 1934, issue of *The Fuel Economist*, which also contains a critical editorial. In this it is stated that it should be remembered that in low-temperature carbonization processes, even when high yields of spirit are obtained, the product of first importance is the smokeless fuel, and for this a primary requirement is low cost. This requirement cannot be made by a process which is based on the use of "waste" coal unless this waste is cleaned. There may be surpluses of such fuel in different districts, but they cannot be classified as waste.

Briefly, any carbonization process today must be based on the use of normally marketable fuel, or it cannot be considered commercially sound. Exceptionally cheap supplies may be taken advantage of, particularly in the early stages of development, but reliance on them is unsafe. During the last few years processes of coal cleaning and preparation, and advancements in combustion equipment, have made the term "waste fuel" almost an anachronism. (*The Fuel Economist*, vol. 10, no. 110, November, 1934, pp. 569–570 for the editorial and pp. 571–574 for the original article. The latter is illustrated by 4 figs.)

Fluorine in Coal

A CASE of severe disintegration of porcelain tower fillings over which hot ammoniacal liquor was circulated in a gasworks, caused the author to investigate the source of this somewhat puzzling corrosion.

It was found that the attack on the porcelain was due to fluorine which was shown to be present in the liquor in appreciable quantities (80 parts per million), probably in the form of ammonium fluoride. After eliminating the possibility of other sources of fluorine, the author was forced to the conclusion that this element had been derived from the coal carbonized in the gas-making process. On examining a sample of the

coal, which consisted of a mixture of Midland and West Country coals, the presence of fluorine was definitely established by the etching of glass.

The existence of fluorine in coal has, the author believes, hitherto not been known, or at any rate, has not been mentioned in the literature. The author has examined a limited number of other coals and established the presence of fluorine in all of them, in amounts not exceeding one part per million.

It has been found that the fluorine content of natural coal dust (containing most of the fusain) is much higher than that of the dust-free coal (vitrain, clarain, durain). This observation indicates that the fluorine is derived from the water which, according to accepted theories, has furnished by a process of infiltration the bulk of the mineral constituents of fusain. On putting this theory to the test it was found that a small portion of fluorine could be extracted by water and a larger portion by a one per cent solution of sodium hydroxide. This distinction proves that the fluorine is mainly present in the form of calcium fluoride. In one of the coals examined, the chloride content in the dust was from three to four times higher than in the dust-free clean coal. As a similar ratio appears to exist between the fluorine contents of the two materials, it is fairly certain that the water with which the coal substance was in contact during or after its formation must be regarded as a source of this element in coal. Moreover, the ratio of fluorine to chlorine in one of the coals examined is of the same order as that found in sea water.

The discovery of fluorine in coals will therefore prove of interest in the study of coal formation. Its practical importance lies in the direction of eliminating coal components, notably dust, from processes in which an accumulation of fluorine might cause difficulties, as in the case which gave rise to this investigation. (R. Lessing, *Fuel in Science and Practice*, vol. 13, no. 11, November, 1934, pp. 347–348)

HYDRAULICS

Design of Propeller Pump and a Centrifugal-Pump Casing

THE author considers the blades of the impeller of a propeller pump at any radius as an infinite series of airfoils; the entrance and exit angles of the blade may then be determined by the theory of momentum imposed on the axis of the impeller shaft.

He then proceeds to show the graphic solution of the problem by establishing velocity diagrams at the entrance and exit edges. By means of this the determination of the form of the blades is simplified. He next considers the velocity of flow in the spiral casing which causes the hydraulic losses including the form resistance.

Several cross-sectional forms of the casing are considered and a formula is given for what the author considers the best and the next best. (Otogoro Miyagi, in Technology Reports of the Tôhoku Imperial University, Sendai, Japan, vol. 11, no. 3, 1934, pp. 287–301, or pp. 21–35, 11 figs.)

The Water-Jet Pump

THE water-jet pump is primarily considered for handling water, but application of it to other fluids merits consideration. For oil-well pumping from shallow wells after gas-lift production becomes uneconomical, experimental results for water under certain conditions can be used. The authors give an example based on a design for oil-well use. Likewise an air-jet pump for mine ventilation is being developed following the suggestion that the mixing chamber be eliminated completely. Operating characteristics of this pump can be predicted with a high degree of accuracy.

The work on the water-jet pump described in the report of which this is an abstract is part of a comprehensive survey of the basic types of water pumps which was started several years ago in the hydraulic laboratory at the University of California. A preliminary examination of this field revealed that the theory of certain types of pumps has been brought to an advanced stage of development without satisfactory experimental verification, while other types had been developed by "cut and try" methods without benefit of theory. Some textbooks on the subject were written from an empirical viewpoint, while others neglected the practical and experimental side of the problem almost entirely. This situation made student instruction difficult and showed the need for a better coordination of theory and experiment.

The number of different physical principles involved in types of pumping machinery is not great. Positive displacement, centrifugal action, changes in density, acoustic waves, and disk friction are the underlying principles in nearly all pumps in use and even these principles are interrelated, since they can be expressed quantitatively in terms of elementary mechanics and the physical properties of fluids. Accordingly, the object of this study is to provide, if possible, a satisfactory theory where one is lacking and to check theory by experiment if reliable data are not available.

The basic principle of the jet pump is the transfer of momentum from one stream of fluid to another. The general class includes injectors and steam-jet air pumps, as well as the water-jet pump, but the latter possesses the decided advantage of not involving either compressibility or heat transfer. Additional work is now in progress on an air-jet air pump geometrically similar to the water-jet pump used in these experiments. It is hoped that the investigation can ultimately be extended to include both steam and oil, or, in other words, to include the effects of compressibility, condensation, and viscosity.

The water-jet pump was first used by James Thomson about 1852, and the theory of pumping by jet action was developed in 1870 by Rankine. The low efficiency of this pump has limited the field of application to conditions in which the absence of valves or working parts and the small size of the unit are sufficient to offset the greater power requirement of this type. This unfavorable circumstance has caused the water-jet pump to receive less attention than it deserves. A number of writers have developed theoretical equations, but almost no experimental data for checking these equations are available. In the present paper the theoretical equations are developed in dimensionless form and an experimental confirmation is presented. The principal aim of the work is to check the applicability of the momentum equation. Refinements in design for the purpose of effecting improvements in efficiency are not attempted, but the results show certain relations which are immediately applicable to practice.

The general theory applicable to an imcompressible fluid of low viscosity, such as water, is fundamentally the same as that developed by previous writers. The treatment involves the computation of friction losses in three pipe lines and the impact loss and pressure change in the mixing chamber. This is given in detail in the original article.

The theory presented is incomplete because it does not consider the details of the mechanism by means of which energy is transferred from the driving jet to the driven jet. Lateral transfers of momentum depending on the velocity gradient and the "mixing length," or, in other words, on the mechanical viscosity or "Austauch coefficient," account for the dragging effect of one jet on the other. However, the net effect is given

by the momentum equations, which are adequate to the present purpose. The details of this mixing process have been investigated by Ledgett (1934) and others.

Methods of computation of efficiency and effect of cavitation are given in the original article. The experimental apparatus and procedure are discussed in detail and the experimental results presented in the form of curves and comments. These deal with such subjects as nozzle discharge, effect of nozzle position, pressure distribution along the mixing chamber, and characteristic curves. The characteristic curves for the pumps tested can be considered as straight lines.

The matter of frictional losses is considered in detail with the usual assumption that these losses are high. Characteristic curves have also been computed for what are considered to be about the lowest possible values of the friction factors. Some possible modifications for the improvement of efficiency are mentioned.

The most important result of this work is the verification of the theoretical equations and the statement of these equations in dimensionless terms. The agreement between theory and practice in the water-jet pump is notably good; any uncertainty in the prediction of the operation characteristics is chiefly to be ascribed to the difficulty of choosing the friction factors which will apply to the flow of a single stream through the same water passages. This is not a major limitation, since the friction coefficients for the suction chamber, mixing chamber, and diffuser can be measured easily by forcing water up through the suction line with the nozzle in place but inoperative. The discharge coefficient of the nozzle can be obtained either during free discharge into the atmosphere or during operation as a pump.

Although the curve of maximum efficiency as a function of area ratio is fairly flat in the region giving the maximum possible efficiency, the choice of area ratio, and hence of the characteristic curve, is limited to the region 0.25 ± 0.10 for the design tested, if a reasonable efficiency is to be attained. For maximum efficiency, the head and quantity ratios are fixed by the area ratio and this relation seriously limits the operation conditions. For example, a small high-pressure pump supplying a small nozzle cannot be used to pump a relatively large quantity through a small head if the efficiency is to approach the maximum value.

The curves in Fig. 9 in the original article indicate that the region of high efficiency becomes wider as the friction is decreased, but the extent to which this improvement can be effected is still problematical. (James E. Gosline and Morrough P. O'Brien, University of California Publications in Engineering, vol. 3, no. 3, 1934, pp. 167–190, 15 figs.)

LUBRICATION

Oil Reclamation

THE article abstracted is a reply to statements attacking oil reclamation. The author shows that whereas operators pay on an average $0.50 per gal for new oil they can reclaim the oil, if the operation is large enough to warrant the installation of proper machinery, for 0.05 to 0.10 per gal. In reply to an attack on the quality of reclaimed oil the author cites references from *Petroleum Age*, *Lubrication*, organ of the Texas Oil Company, *Oil Power*, organ of the Standard Oil Co. of New York, and other publications.

Statements of the U. S. Bureau of Standards and Armour Institute of Technology are here reproduced from the original article.

U. S. Bureau of Standards, Geo. K. Burgess, Director: "The Bureau has analyzed a considerable number of samples of reclaimed crankcase oil and found that many of them show as great excellence in the commonly measured properties as do the so-called new oils. It is believed such oils may be better than new oil."

Armour Institute of Technology, Chicago, J. G. Peebles: "We have often examined reclaimed oils which gave practically the same tests as the original new oils. This test tends to show that lubricating oil does not wear out. There is no reason why such reclaimed oil cannot be used with satisfaction in an automobile engine."

Among the statements quoted in the original article is the following: "The oil can be doctored up to meet exactly the same specifications as the original oil, that is, gravity, flash, fire, viscosity, etc., but every one knows that these specifications or physical properties of the oil do not accurately measure its value as a lubricant." The author of the article abstracted remarks, "If these specifications do not accurately measure the reclaimed oil neither do they accurately catalog new oil." (Henry Jennings, Technical Editor, *Commercial Car Journal*, vol. 47, no. 7, September, 1934, pp. 22–24)

Oxidation Stability of Lubricating Oils

AMONG other things, the relationship between the amount of chemical treatment given an oil and its oxidation-stability number has been tested. The main results are presented in a table in the original article.

It would appear that the amount of acid treatment affected the degree of deterioration of the oil and the general deduction is that as the quantity of acid used in treating identical samples increases, the amount of change in properties of the oil due to oxidation decreases. The tests show also that the difference in property changes between the oils which receive a 10- and 20-lb treatment was greater than the difference between similar oils which have received 100- and 150-lb acid treatment.

A further conclusion is drawn to the effect that the viscosity and source of the crudes from which California lubricating oils are made do not affect the general stability characteristics of the oils. In general, the report shows not only the relative stability of certain oils but also the construction and operation of an apparatus capable of producing in a practicable manner the deterioration of an oil by oxidation, and suggests a method for the evaluation of lubricating oils by their ability to withstand deterioration, due to oxidation, by the method described in the original paper. (Boyd Guthrie, Ralph Higgins, and Donald Morgan, all of the Petroleum Field Office, San Francisco, Calif., U. S. Bureau of Mines, in *National Petroleum News*, vol. 26, no. 33, Aug. 15, 1934, pp. 22–24 and 26, 2 figs. Part 2 of a serial article. The first part is published in *National Petroleum News*, Aug. 8, pp. 22–24, 26, 29, and 32, illustrated)

MACHINE-SHOP PRACTICE

Testing of Forgings for Generator Rotors

ROTORS of large electrical generators are bored out along the axis from end to end. The surface of the bore is usually investigated by means of a periscope and a specially organized system of lighting. As the eye easily gets tired in the course of testing bores of long shafts, the German General Electric Company developed a method in which a special camera is employed. This camera is provided with an automatically guided objective lense which successively scans every point on the surface of the bore and produces a continuous photograph which may be then projected on a screen and

easily viewed. One such photograph with a surface crack in the bore is reproduced in the original article.

The interior of the steel in large forgings cannot be investigated by means of X-rays and therefore a special method of electromagnetic testing has been developed. If a hollow cylinder has a direct current flowing through it longitudinally or across its section (in this case from 2000 to 3000 amperes) magnetic fields are created in its axis, except when the current density is distributed in a perfectly symmetrical manner. This condition can be satisfied only when the material of the forging has no irregularities.

Any crack, cavity, or similar defect causes an appearance of magnetic fields in the interior of the bore. There are certain ways by which the magnitude of irregularities in the material of the forging may be estimated from the magnitude of these fields measured by means of a test coil placed in the bore and moved step by step. For each measurement the coil is rotated through an angle of 180 deg and the current impulse therein measured by means of a ballistic galvanometer.

After the rough cut the forging is subjected to a heating test. In the course of this the forging held on a lathe is turned at a uniform low speed and at the same time slowly and uniformly heated electrically or by a gas flame. It is held for many hours at a uniform temperature and then cooled off just as gradually. Lack of homogeneity in the material, faults, or stresses in the forging produced a distortion during this heating test which can be measured. This test is used by the German General Electric Company for all electric generator shafts, even those subjected to small stresses.

In order to determine the magnitude of initial stresses in forgings, such as used for electric-generator rotors, a comprehensive research was undertaken, in the course of which large high-grade forgings were cut apart in accordance with a predetermined plan and their initial stresses measured. Since these initial stresses are superimposed on the operating stresses, it is impossible, without a close knowledge of the former, to determine the limit stresses and the relation between the strength of the material and the permissible stressing. The report of these tests on specially cut forgings will be found in a paper by G. Kirchberg in *V.D.I. Forschungsheft*, No. 357, Berlin, 1932. (K. Hoffmann in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 78, no. 49, Dec. 8, 1934, p. 1420, 1 fig.)

Effects of Grooves and Fillet Shapes on Endurance of Heat-Treated Steel

TESTS recently conducted in the laboratories of The Spencer Manufacturing Co. would indicate that proper design of grooves and fillets has a very definite effect upon the service obtained from such highly stressed members as automobile and truck axle shafts. The test pieces were all made from 3140 S.A.E. steel, heat-treated in the usual manner and drawn to 321 Brinell.

From the tests it would appear that a specimen having a square neck showed 24 per cent greater endurance than another specimen with a radial groove, in spite of the fact that it has two sharp corners to act as stress raisers. This is ascribed to the fact that the square-necked piece had a better distribution of stress, which means that the stress was allowed to play over the entire 0.1 in. of width, whereas the radial groove forced the stress to concentrate within a very small width at the bottom.

This does not necessarily mean that a sharp corner is better than a fillet, but it may be better if the fillet reduces the available stress area to such an extent that the stress per unit of area is higher than it would have been had a smaller fillet or a sharp corner been used.

It is the author's impression that radii and fillets on shafts have received more than their share of attention in the past, while the aim of the designer should have been a better distribution of stress over the greatest possible area, by making the radii no greater than consistent with the idea above expressed.

For instance, the author's company has come across many cases where a shaft actually could have been reduced to a smaller diameter at certain sections and still have shown much greater resistance to fatigue failure, if some of the lessons taught by these tests had been observed.

The difference between the endurance and the strength of alloy-steel bars is brought out by comparison of the behavior of two test pieces, where both pieces were composed of materials having the same physical strength and both had the same cross-sectional area so that under static load without vibration or fluctuation both should have supported the same load before failure. Under alternative or repetitive stress the two specimens got widely differing results; one showing approximately $5^1/_2$ times the endurance of another. Both strength and endurance are, however, important in design. (Forrest E. Johnson, Research Engr., Spencer Manufacturing Co., in *Automotive Industries*, vol. 71, no. 12, Sept. 22, 1934, pp. 352–353, 7 figs.)

Coining Power Press

THE process of cold coining consists in forming of metal pieces to accurate dimensions. It is often possible to achieve by these means what could otherwise be done only by the more costly operations of milling and surfacing.

The early attempts were unsatisfactory. The heavy pressures required had to be derived from slow working knuckle-joint presses, and it was found that the "spring" in these presses under load was difficult to eliminate and detrimental to the coining process. Furthermore, maintenance costs were excessive. This led to the development of a powerful crank press that was made according to a novel design.

The process is now applicable to such articles as the connecting rod of an internal-combustion engine where the forging can be brought to size and the faces aligned in one stroke of a high-speed press within limits formerly obtainable only by machining.

In the press here described, the framing is a solid heat-treated steel casting weighing 55 tons and reinforced by four tie bars, each 10 in. in diameter. This construction takes care of offset loads, which, in a built-up frame, would cause deflection. The vertical stresses under load are distributed to the preloaded tie bars.

Since spring in any structure is proportional to its length, the distance between the center line of the crankshaft and the bed of the press has been made as short as possible. This has not entailed limitation in the length of the slide.

A pilot bearing is incorporated in the crown, which insures accurate alignment of the slide. The crankshaft diameter is 15 in. and the pressure exerted is 2000 tons. For coining purposes, however, this is rated at only 600 tons, up to which pressure deflection is negligible.

The coupling is solid and non-adjustable to eliminate compression of working parts under heavy pressures. A powerful wedge adjustment is incorporated in the bed. In fact, everything has been done to make the working parts of the press, as well as its frame, solid. This is where such a press scores over those high-pressure machines in which there are to be found a multiplicity of working parts.

The press is provided with a friction slip flywheel which protects the machine from damage due to overloading. In the event of a sudden jam the kinetic energy is released by the flywheel slipping on its

hub between friction disks. Only excessive overload will make the flywheel slip and no adjustments are required afterward. The press makes thirty strokes per minute.

A modern application for a press of this type is in the manufacture of certain press tools. The process is generally called hobbing. The bottom-tool blank is made in the ordinary way and set on the press table. A piece of hot-forged steel is then driven into it by the press, so that it assumes its correct form and only requires to be finished.

In addition to the type described here in which the frame is a steel casting, a compromise form has been developed of fabricated construction made of parts cut out of rolled steel plates. The fabricated construction, among other things, is said to be highly suitable for high-speed bending presses or brakes, such as used for the manufacture of steel furniture, refrigerators, and safes, where perfectly parallel bends are required to enhance appearance. One of the developments in fabricated press construction is represented by the four-point suspensions of the ram. A brief reference to friction screw presses is made. (W. S. Rhodes, second part of a paper before the Institution of Production Engineers, Birmingham Section, England abstracted through *Machinery* (London), vol. 45, no. 1154, Nov. 22, 1934, pp. 324–326, 12 figs.)

PIPING

Stability of Bituminous Coatings for Underground Pipes

THIS paper deals with the testing of bituminous materials whose stability as pipe coatings is to be ascertained, and describes both the standard methods and new methods. Among other things, the author deals with water-absorption tests which demonstrate that, without exception, materials showing a high value for water absorption were those giving poor results on coated plates, and usually the converse was true, except that this test does not reveal lack of wetting effect as disclosed by the coated-plate test.

The test is a very simple one and is described in detail in the original article. The difference between materials was remarkable. Thus coal-tar pitch had an absorption of only about 2 per cent of that of pure Trinidad asphalt. The tests have also suggested that the bitumen does not completely wet the filler.

Experiments are not sufficiently advanced to show if there is any maximum percentage of water absorption by a particular material, or any limiting value for the penetration of the "rotting effect," characteristic of the natural asphalt mixtures, progressively from the surface into the body of the material. A set of tests which may throw some light on this is described in Appendix 3 in the original article, wherein coatings of progressively increasing thickness have been exposed to water and tested electrically, breakdown or insulation resistance being taken as evidence of the penetration of water through the coating.

In tests applicable to finished coatings and particularly tests for pin holes, it would appear that no single-dip coating is free from pin holes, and for good insulation it is necessary to dip and wrap separately, so that each coat may cover the defects in the other.

The remainder of the article is devoted to discussions of properties of a coating as controlled by its process of manufacture. Description of the coating process now used for steel pipe in Melbourne in the laying of coated pipes is given in the original article.

The results of tests have shown that horizontal-retort coal-tar pitch excels all other common bituminous materials in its resistance to water and permanent adhesion to steel. Its mechanical properties leave much to be desired. In the method now used the wrapping compound consists of a mixture of coal-tar pitch and finely ground (200-mesh) limestone used primarily for its mechanical properties of low penetration, high tensile strength, high melting point, and high dielectric strength. Reliance is placed mainly on the inner coating of pure pitch for waterproofness and on the outer wrap for mechanical protection of the brittle inner coating. The practice of rolling the pipe in coarse sand is not favored. (Geoffrey Owen Thomas in *The Journal of the Institution of Engineers, Australia*, vol. 6, no. 10, October, 1934, pp. 337–344 for the original article and pp. 344–346 for appendixes, the last of which deals with economics of pipe coatings, 7 figs.)

POWER-PLANT ENGINEERING

Pipe Joints

THE article describes the refrigerating plant of the artificial ice rink at Basle. Only certain parts of it can be abstracted here. The pipes laid under the ice are of cold-drawn seamless copper of Swiss manufacture. The joints of such pipes must not be subject to attack by brine, electric action, or weather conditions. Soft soldering is not suitable because the tin-lead mixture slowly decomposes through the conversion of tin into tin chloride under the influence of the calcium-chloride brine. Hence, welded joints have been used. In the joints between the copper piping under the rink and the brine-distributing and collecting pieces, stuffing-box joints were used in preference to special expansion bends in the pipes. These joints allow a certain play between the copper pipes under the rink and the brine-distributing and collecting headers. Each separate stuffing box is fitted with an opening which lies opposite the end of the copper pipe and can be closed with a cap. Through these openings each pipe under the rink can be inspected. (Gy. in *Sulzer Technical Review*, no. 4, 1934, pp. 1–3, 4 figs.)

District Heating and Power Station in Zurich

TWO steam generators are installed in the boiler house of the district heating and power station of the Federal Technical University, Zurich. One is a 35-atm two-drum Sulzer boiler with Kablitz overfeed firing, and the other a 100-atm Sulzer high-pressure single-tube steam generator with Steinmüller zoned traveling stoker and additional oil firing. The steam at 100 atm pressure passes first through a primary turbine and then into the 35-atm system, in which a back-pressure extraction turbine and a condensing turbine with double extraction are included. These turbines supply extracted steam to the 10-atm and to the 1-atm systems. The existing steam-heating installations in the hospital and in the chemical laboratory are served directly from the 10-atm system, while the steam at 1 atm serves for heating the hot water in the countercurrent apparatus, and also for supplying service water.

An interesting detail in connection with the double-extraction condensing turbine is the unusual arrangement of the set, the two casings of the turbine being arranged parallel with each other. The low-pressure unit is connected directly to the generator, while the high-speed high-pressure unit drives the generator through a gear with three shafts. It is consequently possible to put one or the other of the turbine units out of operation. The coupling is arranged in such a manner that the gear is at rest when the high-pressure part is shut down.

For carrying out experiments on steam-turbine blading a two-stage overhung turbine has been provided. The shaft is of practically rigid construction in

order to insure freedom from vibration at all speeds up to 9000 rpm. The provision is made for determining the loss in the bearings. The guide wheels are not rigidly connected to the casing but are arranged to turn on a shaft and can be moved axially. The guide-wheel shaft serves also for leading the steam to the turbine. The movable arrangement of the guide wheels makes it possible to determine the reactions both axially and circumferentially. Readings can be taken without any previous adjustment and the distance between guide wheel and impeller can be maintained if once established.

The heat-pump principle is represented by an evaporating plant, which allows 800 kg of distilled water to be prepared in an hour. The compressor is not driven, as is usual, by an electric motor, but by a back-pressure steam turbine. In the turbine the steam pressure drops from 10 atm to 2 atm, while in the compressor the vapors are compressed from 0.1 to 0.5 atm. The vapor compressor and the turbine driving it, therefore, constitute, in principle, a steam-transforming set, in which a large drop in pressure unsuitable for certain condensations is utilized with a small quantity of steam, in order to compress a larger quantity of steam through a difference in pressure which is smaller but more suitable for the process in question.

Combining a district-heating power station with the engineering laboratory of the Technical University is a happy solution. Here the students are given an opportunity of making themselves acquainted with an important branch of practical work, and to carry out tests and investigations on machines and apparatus which are of an unusual capacity for university conditions. The district-heating power station serves in addition to the federal and cantonal buildings, many private houses, and new schemes for extending the district served are under consideration. (Rg. in *Sulzer Technical Review*, no. 4, 1934, pp. 4–11, 11 figs.)

The Diphenyl Heat Engine and Findlay Cycle

DIPHENYL has been extensively used as a heat-transfer fluid in drying, distillation, evaporation, etc., and has been considered for possible use as a heat-engine fluid. This last use, however, has not been attempted to any great extent because diphenyl superheats upon expansion when practically one-third of the total heat is changed into superheat, but of the latter only some 12 per cent is available as superheat, while the remainder must be regarded as useless in so far as the engine is concerned.

In order that the diphenyl engine may be comparable with modern steam cycles in the matter of ideal efficiency, the regenerative process must be an integral part of the cycle. It is not an easy matter, however, to regenerate about 150 Btu of superheat per 1 lb of vapor in the temperature range of 300 to 800 F.

Dr. W. S. Findlay, by evolving what he has termed the dual or "partial" regenerative cycle, has succeeded in overcoming this difficulty of regenerating superheated vapor, and in extracting approximately 60 per cent of the vapor supply to the engine, and this vapor contains no more than some 12 heat units per pound of vapor in the form of superheat which is easily desuperheated and condensed in the usual type of extraction heater. The vapor that remains in the engine superheats, of course, and that which is not usefully used, or extracted, is presumed, in the ideal cycle sense, to be desuperheated after expansion, and, of course, before condensation of the vapor. In the opinion of the author, this is perhaps the most ingenious heat-engine cycle yet devised, for it not only applies the established economic principle of regenerative feed heating, but also removes the otherwise insurmountable difficulty accentuated by the restricted conditions of heat-engine design and operation of absorbing superheat. Perhaps the most spectacular feature of this dual-regenerative cycle is that its ideal thermal efficiency is always in excess of the so-called limiting efficiency expressed by the Carnot relation: $(T_1 - T_2)/T_1$.

If we accept the limit of temperature for economic heat-engine operation to be 800 F, the dual regenerative cycle working between the pressure limits of 222 lb per sq in. and 1 lb per sq in. abs, and within the range of 320 to 800 F has an ideal thermal efficiency of 44.1 per cent, and is comparable with the expensive modern reheating regenerative steam cycle working in the pressure range 1000 to 1 lb per sq in. and the extended temperature range 100 to 800 F. The rejected heat of the diphenyl cycle is available at 320 F, and naturally invites utilization in one way or other, such as the production of steam which can be superheated by the extracted diphenyl vapor. If this rejected heat is so used, producing saturated steam at 320 F and using extracted heat to superheat it to 795 F, and the steam adiabatically expanded to 1 lb abs pressure in a regenerative cycle wherein the condensate at 101 F is regeneratively heated to the freezing point of diphenyl (157 F), the calculated ideal efficiency of the combined diphenyl-steam cycle is no less than 57.5 per cent. This is a surprisingly high efficiency; it is by far the highest ideal efficiency claimed for any vapor heat engine, binary or otherwise, working within the same temperature range; compared to the Carnot cycle it is some 2 units per cent higher, the Carnot efficiency being 55.5 per cent.

The original article contains an ideal cycle diagram. It is shown that the ideal thermal efficiency is 44.1 per cent and the Carnot efficiency 38 per cent. The difference is due to the regenerative process together with the fact that useful work is done by the superheat without increasing the condenser loss above that normal to the Carnot cycle. The regenerated heat is available at a temperature of 320 F and may be possibly reclaimed.

The original article also contains a composite diagram of the dual regenerative diphenyl steam cycle. There are interstage extraction heaters and two interstage coolers for the diphenyl process. The steam process has one extraction stage, and this part of the combined cycle has been divided in the diagram into its constituent parts, namely, sensible, latent, and superheat. The weights of diphenyl and steam and the differences in their latent, sensible, and specific heats do not permit the combination of the two processes in one conventional diagram without overlapping. The ideal efficiency of this diphenyl-steam cycle is 57.5 per cent. There are 56.6 Btu at 320 F available from the rejected diphenyl latent heat, which is used to supply sensible and latent heat to a regeneratively preheated feedwater supply at 157 F for the production of steam at 320 F, saturation temperature.

The superheated steam temperature is 795 F, and this figure has been chosen since steam, at 89.9 lb per sq in. abs and 795 F final temperature, has an entropy value or rank equal to dry saturated steam at 157 F, at which temperature extraction begins, the extracted vapor being condensed and mixed with the main condensate at 101 F (condenser temperature). The regeneration temperature of 157 F is adopted since it corresponds to the freezing point of diphenyl.

The main operative data of the ideal cycle are given in the original article with the following comment by the author of the original article. "The cycle is remarkable; the possible efficiency eclipses that of any other practical form of heat engine working within

a similar range of pressure and temperature. The relatively small heat drop per pound of diphenyl vapor is no disadvantage since diphenyl vapor within the pressure range considered is approximately ten times heavier or more dense than steam at similar pressure. A diphenyl unit should therefore be smaller than a steam unit of equal output, and for the higher steam pressures certainly not larger. Moreover, the high relative density of the vapor will permit of a relatively low speed of rotation and thereby reduce frictional and windage losses common to steam-turbine practice."

From the article it does not appear that a unit operating on this cycle has been actually built. (*The Steam Engineer*, vol. 4, no. 2, November, 1934, pp. 53–55, 2 figs., *dA*)

How Much Oil Should a Steam Turbine Carry?

THIS article is based primarily on the experience of the Berlin City Electricity Co., Berlin, Germany, generally known as Bewag. The oil in the steam turbine is used primarily for purposes of lubrication, but may have to be relied upon to carry off substantial quantities of heat.

Excessively frequent changes of oil, such as may be brought about by carrying an insufficient quantity, are undesirable, as the time that the oil is held in the containers is not sufficient to permit foreign matter, such as particles of metal and water, to settle out. Where the oil has to carry off substantial amounts of heat and the reserve of the oil is excessively small, or the oil coolers inefficient, trouble may arise owing to the fact that when oil is intimately mixed with air it is more than otherwise subject to oxidation, particularly at the higher temperatures. Therefore, where an insufficient amount of oil is used as a vehicle for heat, deterioration of the lubricant is accelerated. Because of this the author recommends that the temperature of the bearings should not under any conditions exceed 70 C, while the temperature of the oil at the entry to the oil cooler should not exceed 60 C.

Because of the unfavorable effect of increase of temperature on the life and performance of lubricating oil, the author considers it undesirable to place oil power drives directly next to the governor valve. Such a construction leads to the heating of the oil and its consequent deterioration. The author recommends as a means of increasing the life of turbine oil that a small amount of the oil be led through a centrifugal separator placed in a bypass to the main mass. He also recommends that the lower part of the oil container be made of conical shape so as to favor the segregation of any foreign matter contained in the oil by having it settle in the lowermost part of the oil container.

The author claims that the amount of oil that a turbine should contain can be determined analytically from the design of the turbine parts on which the circulation of the oil depends. A check-up from this point of view has been made in the plants of Bewag containing 52 turbines made by different manufacturers and different in size and age. Excluding

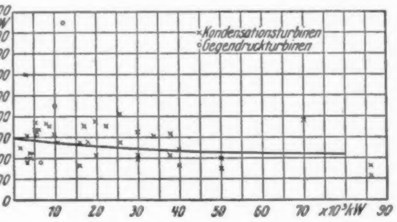


FIG. 2 SPECIFIC OIL SUPPLY FOR CONDENSING AND BACK-PRESSURE TURBINES

(*Gegendruck* = back pressure.)

duplicates, 31 units made by six manufacturers between 1906 and 1930 were available, these turbines being condensing, back-pressure, and various kinds of bleeder types with outputs of from 1500 to 70,000 kw.

It would appear that there is a definite relationship between the amount of oil that the turbine should carry and turbine output, and a curve in Fig. 1 in the original article shows that a practically linear relationship between the amounts of oil to be carried and turbine output exists up to about 40,000 kw. Fifteen condensing turbines with outputs in excess of 40,000 kw are also represented on the same curve and indicate a flattening of the curve for the very large turbines.

Fig. 2 shows that the amount of oil increases with the increase of turbine output in a ratio which indicates a certain reduction of the specific oil reserve (in kg per kw) with an increase of turbine output. The points in either of the two illustrations are fairly scattered, which the author takes as an indication of the effect on the amount of oil produced by the design of the turbine.

As compared with condensing turbines of the same output, back-pressure turbines in practically every instance show a much greater amount of oil. This may be explained by the fact that in the case of back-pressure turbines, the amount of heat that must be carried off by the oil is materially greater than in condensing turbines of the same output. Whereas with the latter the temperature in the exhaust steam pipe can rise only to about 50 C, the temperatures in the back-pressure type are very much higher. An unusually large amount of oil is shown by the 70,000-kw turbine made by the German General Electric Co. This turbine is of the two-shaft type and the greater amount of oil may be due to the larger number of bearings.

The amount of oil to be carried is materially affected by its turnover. The number of times the oil circulates per unit of time gives an insight into the relationship existing between the amount of oil and the design of the turbine parts which cause the oil turnover. As has been pointed out before, excessively rapid turnover is undesirable from a chemical point of view (by turnover the author means here the number of times the entire mass of oil circulates per hour).

This turnover is determined by the amount of oil present and the output of the oil-circulating pump. An excessively rapid turnover in itself does not show whether the amount of oil available is too small or the output of the pump too large, as there is another factor which must be taken into consideration and that is the amount of heat that the oil must carry off. A very high turnover factor in itself indicates, as a rule, that there may be an unnecessarily high stressing of the oil.

Fig. 3 in the original article shows the turnover factors for a given set of turbines. The figures lie mainly in the region between 6 and 11 hours and there are both very low and very high figures. These are elsewhere discussed in this article. In general, 8.5 times per hour seems to be the average turnover.

A factor of the highest importance affecting the life of oil is the amount of heat that the oil has to carry off. The factors that affect the oil are number of revolutions, design, size, and number of bearings, and bearing pressure. Taken one by one none of these factors seems to affect the oil directly, and the yardstick for measuring the total effect of all of these factors taken together is the amount of heat that the oil carries off per unit of time. This amount of heat can be determined comparatively easily from the amount of oil present, the turnover factor, the specific heat of the oil, and the temperatures of the oil at the inlet to and exit from the oil cooler, the latter of which depends on the size of the surfaces of heat transfer in the oil cooler and the amount of cooling water.

However, for the calculation of the

heat carried off by the oil, the factors of oil-cooler design and amount of cooling water present are immaterial, since, for the purpose here discussed, it is not the actual temperature but the temperature difference that is necessary in determining the amount of heat carried by the oil. For the range of temperatures with which we have to deal here, namely, 20 to 100 C, and the oils chiefly used for turbine lubrication, the average specific heat of

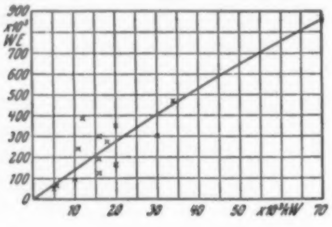


FIG. 3 HEAT CARRIED OFF BY THE OIL PER HOUR

the oil is 0.45. The oil-cooler inlet and outlet temperatures should be measured as far as possible at full output of the turbine.

Fig. 3 contains some data of measurements and a curve showing the relationship between the size of turbine and the heat carried off by the oil. Another figure indicates the relationship between the amount of oil present and the amount of heat handled for the various sizes of turbines. A flat curve is indicated.

The amount of heat carried off by the oil is the product of the available oil supply a, turnover factor z, specific heat of oil c, and the difference of temperatures Δt at the inlet and outlet of the cooler, from which the available oil supply a can be expressed by the formula $\frac{WE}{zc\Delta t}$ where WE is the heat in kcal.

The author suggests the following values for the quantities used here $z = 8.5$, $c = 0.45$, and $\Delta t = 12$. Since z and Δt are constants, the dimensions of the oil circulating pumps and heat-transfer surfaces in the oil cooler must be selected so that the oil temperature at the entrance to the cooler will be a maximum of 60 C. In the calculation of available oil supply it is assumed that the factors accelerating the aging of the oil and possibly bringing about its complete breakdown, such as excessively high turnover or heat loads on the oil, will be eliminated.

The original article contains a very interesting table representing a comparison of the calculated and actually available oil supply, in which information is given as to 20 turbines, including the name of the manufacturer of turbine and generator, its output, turnover factor, amount of heat handled by the oil per hour, output of the oil cooler in kg per sq m per hr, and the amount of oil available calculated as being necessary. From this it would appear that in some instances the calculated oil is nearly twice as much as the oil actually available, though in the majority of the cases it is less.

The following comments are made on the individual units. One unit consists of a M.A.N. back-pressure turbine with a Siemens-Schuckert generator, the turbine having an output of 65,000 kw. It has a turnover factor of 10, and an available supply of 1200 kg as compared with the supply calculated as necessary of 2000 kg. It has been found that the comparatively large heat load on the oil which must be handled by means of an excessively small oil supply available, has an unfavorable influence on the behavior of the oil, as no matter what kind of oil of a given viscosity has been used in this turbine, the oil has not lasted long. Fig. 4 shows the aging of this oil. Because of a feeling that the supply of oil in this turbine was excessively small, the supply was increased by 1000 kg several months before this article was written, giving a supply of 2200 kg closely approaching the calculated amount.

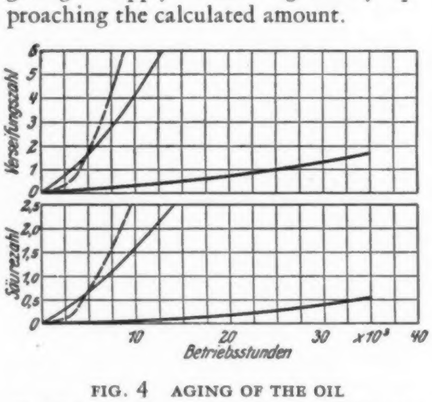


FIG. 4 AGING OF THE OIL

(Solid heavy line = normal aging; thin line = aging of oil No. 1; and broken line = aging of oil No. 2. Abscissas, hours of operation; ordinates, in the lower set of curves, acidity numbers; ordinates, in the upper set of curves, saponification factors.)

A somewhat similar condition was found in the case of an A.E.G. turbine of 10,600 kw. In order to carry off the heat the oil supply has to turn over 21 times per hour. This is entirely too small, as instead of the available 2900 kg there should have been 5375 kg. The result is that after only 2000 hr of operation the oil shows a more than normal amount of aging expressed by an acidity of 0.36 and a saponification factor of 1.34. The same is true for a 16,000-kw A.E.G. turbine carrying a supply of 2600 kg instead of 4275 kg determined by calculation. Here again a turnover factor of 21 times per hour is found, and the overloading of the oil by heat is clearly indicated by the oil consumption of from 270 to 300 g per hr as compared with 150 to a maximum of 200 g per hr of other turbines of similar size and even greater number of bearings.

On the other hand, the same table would indicate cases where too large a supply of oil has been provided. Thus, in the case of the 70,000-kw A.E.G. turbine, this supply could have been reduced from 27 tons to 19 tons with a corresponding saving in capital. (Dr. of Engrg. H. Richter in *Elektrizitätswirtschaft*, vol. 33, nos. 16 and 18, Aug. 31 and Sept. 25, 1934, pp. 322–325 and 371–373, 9 figs., 1 table)

STEAM ENGINEERING

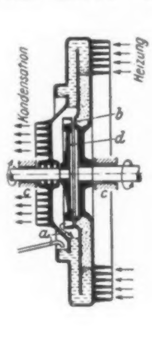
The Huttner Turbine

ONE of the purposes of this device is to combine the boiler and turbine in such a manner as to eliminate most of the control apparatus. To do this the boiler has been attached to the turbine in such a way that it rotates with it. As shown in Fig. 5, one of two communicating water spaces is heated (*Heizung*) and steam in that chamber is generated. Pressure is created because of the throttling effect of the steam nozzles, and the water level, which is here of cylindrical shape, is displaced outward until it is counterweighted by the column of liquid in the other chamber. The flow of steam through the nozzles and the turbine wheel produces torque on the turbine wheel and the body of the boiler, but the directions of these torques are opposite. If, now, the steam is condensed in the housing, the condensate under the action of centrifugal force flows back into the feedwater and the circulation takes place automatically without any outside interference.

The fundamental principle governing this process is as follows: The turbine housing is built to act as a rotating body and carries on its periphery spaces for the formation of steam and excess of feedwater. The steam pressure generated is forced by the mass of water acted upon by centrifugal force against the inside of the turbine housing, so that the steam can follow only a predetermined path through nozzles. The centrifugal force also separates from each other, by means of columns of water, chambers under different steam pressures. The equalization of the various pressures leads finally to the difference in the

diameters of the water surfaces. The greater the centrifugal force and hence the number of revolutions per minute, the smaller is the difference in diameter of the water surface under an assumed difference of pressures. For cold water, for example, where the peripheral velocity on the inside surface is 60 m per sec and the velocity of the outside surface 80 m per sec, there is a difference of pressure equal to 14.3 atm. This shows that, in this case, velocities are manageable.

The principle of sealing the chambers subjected to different steam pressures by means of liquid masses subjected to the action of centrifugal force is further applied in the case of a multi-stage turbine shown diagrammatically in Fig. 6.



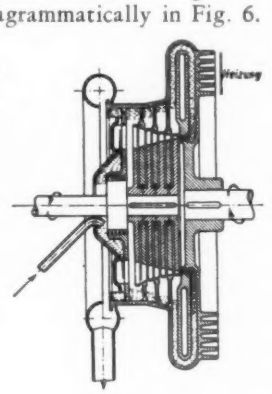


FIG. 5 (LEFT) DIAGRAM OF THE SINGLE-STAGE HUTTNER TURBINE
(a = water inlet; b = steam nozzle; c = bearing; d = rotor.)

FIG. 6 (RIGHT) DIAGRAM OF THE MULTI-STAGE TURBINE

Here the chambers exposed to intermediate pressures, just as in the case of a single-stage turbine, are connected with the feedwater chamber. In accordance with these pressures, several water levels are produced, and this arrangement has inherent in it the possibility of automatically separating the water produced in the expansion of the steam and of preheating the feedwater by means of interstage steam.

Since the rotating housing represents an intensively operated centrifugal, the water produced as a result of the expansion of steam cannot be carried over into the next stage. It is ejected by the centrifugal force, particularly at the places where the velocity of steam is low at the back of the rotor disks. In this way, the water produced from the expansion of the steam is led back into the circulation system without any loss of heat, and each subsequent stage can operate with dry steam.

The contact of the water levels with the steam in its various stages condenses a portion of the latter, and hence produces regenerative preheating. This process occurs in all the stages and finally ends in the condensation chamber which is of the injector-condenser type.

The working liquid in the condenser is ejected therefrom over an externally located "water cup." This cup is at all times filled to the brim, and as it communicates with the feedwater chamber, it determines the diameter of the water surface for the entire system as a function of the atmospheric pressure. In chambers where the pressure is less than atmospheric, the water surface moves inward, far enough to keep the water column thus produced in balance against the atmospheric pressure. Higher pressures force the corresponding water surface further outward. Moreover, the water cup supplies the system at all times with feedwater, automatically controlled.

The return to the system of the water formed in the expansion of the steam and the ability of the stage steam to take up the heat of condensation in the feedwater makes the process a close approximation of the Carnot ideal, which, in other apparatus, can be attained only by means of complicated machinery. The formation of water as a result of the expansion of the steam causes trouble because of erosion in conventional types of turbines and must be restricted by means of high superheat of live steam and interstage superheating,

Recognition of the importance of high steam temperatures makes possible an entirely novel design. Heretofore, machine parts exposed to high temperatures have been a necessary evil. In this case the attainable steam pressure depends on the speed of rotation only. In this case it is lower with superheated steam than with saturated steam. The thermal disadvantage of saturated steam as compared with superheated steam is taken care of by the higher initial pressure, with the result that the use of saturated steam has advantages and no disadvantages.

As a matter of fact, however, the heat-exchanging surfaces of the steam generator are actually not designed like those shown in the drawings illustrating the principles of operation of this apparatus. In order to utilize completely the effect of heat transfer, which, because of the higher relative velocities between heated surfaces and the heating medium, is particularly large, these surfaces have been generously subdivided. The two communicating chambers have been replaced by single U-shaped tubes and, in general, are so designed as to force the passage of the hot gases between the boiler tubes.

The author refers to two units which have been built in accordance with the principle described. The first tiny unit had a boiler with an outside diameter of only 210 mm and was built primarily to establish the process of forming the steam. It was found, however, that it was capable of giving important test data. Its steam output from the boiler surfaces in contact with the heating gases was 200 kg per sq m per hr; the steam output of the boiler surface in contact with water was 1500 kg per sq m per hr; and the loss of heat necessary to produce the rotation of the boiler was 2.5 kcal per kg of steam.

The rotation of the boiler is induced by the reaction impulse of the nozzles and is braked by the ventilating action of the hot gases. It is entirely free and the speed of rotation varies in accordance with the amount of heat supplied. With the steam necessary to start the turbine, the speed is 2800 rpm and at full heating and full load on the turbine, it is 5000 rpm. The corresponding steam pressures at the nozzles are 0.9 and 5 atm gage. The turbine runs at 17,500 rpm and drives a small generator through a 1 to 3.9 gear reduction. The electrical output at the bus bar is 100 watts, and at the coupling 208 watts. The boiler efficiency over the entire range of loads is 80 per cent.

The unit next built had an output of 300 kg of steam per hr at 16 atm gage and was provided with an air preheater and jet condenser. It is said that this unit was entirely satisfactory. (Fritz Hüttner in *Elektrotechnische Zeitschrift*, vol. 55, no. 30, July 26, 1934, pp. 742–744, 7 figs.)

THERMODYNAMICS

Analysis of the Ejector Cycle

THIS is a mathematical article not convenient for abstracting. An interesting feature is that it makes use of the theory of conservation of momentum and comes to the conclusion that Stodola's analysis of the cycle is not satisfactory. A numerical problem is given to illustrate the theoretical method. The use of ammonia for both the motive power and the refrigerant in the ejector system is shown to be an absurdity, and the only thing that can be said for it is that the necessity of purging is eliminated. (Peter Kalustian, Wecoline Products, Inc., Boonton, N. J., in *Refrigerating Engineering*, vol. 28, no. 4, Oct., 1934, pp. 188–193 and 208, illustrated)

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers, A.S.M.E. Activities

Suggestion Systems

AT THE 1934 Annual Meeting of The American Society of Mechanical Engineers two papers on suggestion systems for employees were presented and discussed. One of these papers "Suggestion Systems," by Z. C. Dickinson, appeared in the November, 1934, issue of MECHANICAL ENGINEERING, and the other "The Operation of a Suggestion System," by Virgil M. Palmer, was published in the December issue. Discussion on both of these papers received in writing follows:

BY ALBERT S. REGULA[1]

The interest in suggestion systems is widespread, several hundred companies in a variety of business organizations having adopted plans of one kind or another in the effort to secure for industry "the positive and constructive ideas of workers about products and methods" of which Professor Dickinson speaks. However, the experience under suggestion systems is not altogether one of success, for many suggestion systems have been short-lived, having foundered on the rocks of employee indifference.

We are fortunate, therefore, in having before us for discussion the papers by Prof. Z. C. Dickinson and Virgil M. Palmer. The former is a comprehensive presentation of the fundamental philosophy behind suggestion systems combined with a critical statistical analysis and appraisal of their operation. The latter is a detailed presentation of the operation of one of the earliest of suggestion systems established in American industry, indicating the successive changes resulting from experience, the details of administration, and an appraisal of results. I fully subscribe to and endorse the fundamental principles which a careful study of the papers reveals.

There is assuredly no one system applicable to all situations. Within certain limits each company must necessarily work out the details of a suggestion plan to fit its own peculiar conditions. There has been, however, sufficient uniformity in the practice and experience of companies which have endeavored to stimulate employees' suggestions through organized plans to suggest what those limits are. It may be of value to summarize, however briefly, the fundamental principles as set forth in these papers and to indicate the few general guides, based upon the cumulative experience of many companies, which should be observed with reference to suggestion systems.

(1) The plan must be energetically and persistently "sold" by management, particularly to those who hold any position of authority in the company. "Foreman resistance" is not a "smoke screen" thrown out in defense of a plan failing of its objectives; it is an actuality. The rotating membership of the suggestion-award committee among department heads and the eligibility of foremen for suggestion awards under the Eastman plan are practical aids to this end.

(2) There should be a clear and definite statement of the plan, the scope and nature of the suggestions and basis of award, and other essential details.

(3) The eligibility of various classes of employees to awards for suggestions should be definitely provided for. There is wide difference of opinion as to the eligibility of foremen. Many hold that the wage earners constitute the only logical group for eligibility and that inclusion of the foremen arouses suspicion on the part of employees when suggestions are rejected. The Eastman experience in this respect is interesting. The practice is followed by many companies of making supervisors eligible to submit suggestions affecting the work or methods of departments other than their own.

(4) The scale of awards should be definite, adequate enough to serve as an incentive, and bear some tangible relation to the net saving accomplished by the suggestion. I commend a most careful study of Professor Dickinson's exceptionally complete treatment of this all-important phase of the subject, to which I would simply add that it should be made clear to employees that many suggestions become valuable only after they have been improved and made workable through further research and the efforts of management. And, further, whatever system of awards is adopted, provision should be made to insure as nearly uniform valuation of suggestions as possible.

(5) Depending upon the size of the unit, full or part-time investigators or secretaries to the suggestion-award committee should be appointed to look after the details of and to insure prompt action on suggestions. Mr. Palmer very properly emphasizes the value of encouraging employees to contact the suggestion secretary, as it broadens the viewpoint and understanding of employees and not infrequently brings out good ideas which were concealed because of the inadequate way in which the suggester expressed himself in writing.

(6) There should be a definite procedure for receiving, acting upon, and making rewards. The prompt acknowledgment and consideration of suggestions are essential to the proper working of a suggestion system. If a suggestion requires some time to investigate or experiment with, the suggester should be kept posted as to the progress being made. Above all, the suggestion-award committee should be impartially chosen and so constituted as to command the respect of all employees.

(7) When a suggestion is not adopted, the specific reasons for the rejection should be given. It must be recognized that there will be cases of dissatisfaction, charges of prejudice, and a feeling of unfairness on the part of some employees, and every effort should be made to insure that the suggester thoroughly understands the reasons for, and concurs in, the rejection. In this same connection, steps should be taken to protect the interest of those whose suggestions were originally rejected but which were adopted at a later date in whole or in part.

(8) The mechanics of the system must be such as to instil in the minds of employees the confidence that their interests in advancing suggestions are fully

[1] Industrial Relations Counselors, Inc., New York, N. Y.

safeguarded. Great emphasis is placed, at times, on the need for keeping the name of the suggester anonymous until the awards have been determined. It is difficult for me to justify secrecy in any personnel procedure. The knowledge of the identity of the suggester does not in itself induce unfairness. The need for concealment may be an indication that the relations between supervisors and employees are not altogether wholesome and that proper employee confidence does not exist. The Eastman plan strikes me as offering a practical answer to the question, the decision being left with the suggester. Strikingly enough, 81 per cent of suggestions received in 1933 were signed.

(9) Non-financial incentives—certificates, publicity in plant paper—may sometimes serve more appropriately as rewards for suggestions of minor or intangible value than a low cash award.

(10) Constant and well-planned publicity—plant paper, bulletin boards, posters, local papers in small communities—is essential in maintaining employee interest in the suggestion system.

BY C. S. HAMILTON[2]

My discussion of Professor Dickinson's paper is based upon first-hand experience as chairman of a suggestion system that has functioned satisfactorily for a period of more than fourteen years. Our system is built on the "individualistic" plan. Suggestions are submitted on the strict assurance that, during the process of consideration, the author's name shall be known only to the chairman and the secretary of the committee, and not until announcement of the award is made by bulletin, or in the house organ, is the name of the author revealed. In case a suggestion is rejected, the author's name remains confidential, with this exception; that it is recorded on a master card in the employee's record of employment.

I am of the opinion that a suggestion system without a definite plan is useless. It only tends to create distrust, discontent, and allegations of managerial preferment.

A well-organized system should embrace the following essentials: Confidential presentation, impartial consideration, prompt disposition, adequate publicity of awards, managerial commendation, and employee-record notation.

The chairman should be familiar with the corporate organization, preferably from a general department, and the personnel department, if one exists. The members of the central committee should be held to a workable minimum (eleven, including the chairman, in our organization of approximately eight thousand employees), evenly balanced, representing men and management. All suggestions should be submitted anonymously and confidentially. The identity of the author should not be revealed to any person, not even to the committee members, until after the award has been made. In some instances, for the purpose of intelligent consideration, it may become necessary to reveal the job specifications or occupation of the author to either the department or the central committee, at the discretion of the chairman.

Irrespective of the apparent value of a suggestion, it should have careful consideration and courteous communication by way of personal letter to the author, if rejected. To criticize or ignore a seemingly valueless suggestion may kill the initiative of an employee and become a barrier to further suggestions of possibly immeasurable value.

Suggestion stationery should be supplied through easily available receptacles or suggestion boxes. Prompt conveyance by plant or United States mail in confidential envelopes should be maintained. A suggestion should be in the hands of the person interested within twenty-four hours from the time it is received by the secretary, if possible. The central committee should meet monthly on a stated day. All suggestions outstanding for a period of more than thirty days should be followed up. If delay is occasioned longer than thirty days, owing to analysis, trial adoption, financial reasons, or other causes, the chairman should acknowledge the delay by personal letter, stating an approximate date that the suggester may expect consideration of his suggestion.

Bulletins listing the names of award recipients should be posted following the committee meetings. A photograph, together with an abridged personal and employment history, and a brief description of the suggestion, should appear on the bulletin, also in the plant organ, when major awards are given (in excess of $25). This has some moral effect on an employee in that he is keenly desirous of seeing his name in the commendatory list rather than in the list of names announcing $5 awards of which no description appears.

Outstanding or major awards should be brought to the attention of the executive in charge, and personal letters of congratulation and commendation written to the reward recipient. The chairman should acknowledge all suggestions by personal letter and upon information furnished give a logical reason if and when a suggestion is rejected.

Suggestions submitted should be made a part of the employment record and a factor when considering an employee for advancement in position and/or monetary remuneration. Executive pronouncement of this policy, however, is controversial, since an employee may attach greater importance to his suggestion record than to his service and efficiency.

From our experience it has been found that a minimum of less than $5 for an adopted suggestion is not practical. If a suggestion is worth anything it is worth at least $5. There should be no fixed maximum. Percentage of saving as a base for evaluation is not practical, since a large percentage of suggestions, particularly those dealing with safe practice, health and sanitation, good housekeeping, and improvement of employee and public relations are of intangible value upon which no accurate estimate of saving or monetary income can be placed. Therefore, an arbitrary award based on elastic precedent, initiative, originality, and effort involved, together with such monetary value as can be determined, seems to be the most practical and satisfactory method.

The value of a suggestion system is largely intangible. However, it is my opinion that if we take into consideration only those suggestions upon which a tangible value can be placed, it pays 100 per cent on the investment. Some of the outstanding results of a properly organized suggestion system are as follows:

(1) Improvement of employee relations
(2) More satisfactory public relations
(3) Prompt revision or elimination of obsolete forms and practices
(4) Improvement in health and sanitary conditions
(5) Advancement in operating efficiency.
(6) Better housekeeping
(7) Orderly arrangement of materials and machinery
(8) Reduction of fire hazards and cost of fire insurance
(9) Reduction of personal accidents, resulting in lower compensation rates.

A suggestion system properly organized, aside from its monetary value, is a most efficient adjunct to any large organization. It provides a means for ironing out and eliminating many troublesome and irritating problems that occur between employees and management. It has its value, although to a lesser degree, in small plants. [Additional comments on this subject will appear in later issues.—*Editor*.]

[2] Welfare Manager (Chairman, Committee on Suggestions), Philadelphia Company and Subsidiary Companies, Pittsburgh, Pa.

Wine Makers and Bottle Makers

TO THE EDITOR:

The American Society of Mechanical Engineers was formed and operated for years for the purpose of consideration of engineering problems. There are, in our present complex civilization, many other very important problems, perhaps even more important than those of the mechanical engineer. Among these may be mentioned the problems of religion, immortality, health, administration, and economics. Many of us have pronounced ideas about many of these subjects, and would like to hold forth on our own ideas to our fellows. The writer, for instance, thinks that his views on Unitarianism are well worth the attention of his fellow engineers.

However, it is not considered proper to give our publications over to any of these important extraneous subjects, except economics. The editors and committees seem to consider that this one of all of the important extraneous subjects is worthy of considerable space. This whole subject is very well analyzed by the parable of the wine makers and the bottle makers by Professor Karapetoff in the December, 1934, *Electrical Engineering*, page 1681. I would liken the wine makers to the engineers and the bottle makers to the students of administration and economics.

Our own society is already reaching one of the steps mentioned in Professor Karapetoff's parable, in the formation of a small professional circle of those interested in Applied Mechanics, who have found it necessary to publish a journal all their own, because our Society does not see fit to publish all of the strictly engineering matter which is available.

In order to give point to this letter, I hope the editor will be broad-minded enough to reprint Professor Karapetoff's parable.

SANFORD A. MOSS.[1]

PROFESSOR KARAPETOFF'S PARABLE[2]

A certain country was noted for its wonderful native wines, both sparkling and mellow. Grapes were grown by small individual owners, and each specialist was proud of his product and of its distinct taste. For fermentation and aging, wine was poured into various casks, skins, bottles, jugs, etc., as the case might be. From time to time there was some talk about the containers being not always satisfactory and certainly not uniform. Gradually the makers of bottles and jugs organized an association to improve and to standardize their products, so as to provide the wine makers with better containers and thereby to assist them both in the production and marketing of the wines.

It so happened that while it was easy for bottle makers to become organized (their product being standard and comparatively easy to manufacture), the wine makers continued their individual production, at least for the choicest vintages, where intimate individual knowledge, skill, and professional pride were important factors. As time went on, there was more and more talk about excellent bottles and less and less talk about the wines themselves, because the organized bottle makers had better publicity channels. In some cases fancy mass-production bottles began to be used for mediocre wines, thus discouraging the best viniculturists.

To make the situation worse, the bottle makers conducted their activities as part of the wine-making industry, and the wine makers were only invited from time to time as a favor to sit with them in their discussions. To make the camouflage complete, the bottle makers adopted for themselves the honorary degrees which the wine makers originally used to bestow upon their own distinguished confreres, such as master of fizz and doctor of fermentation, although the recipients from among the bottle makers did not even understand the meaning of the words. Every time an intricate technical problem in wine making arose, the bottle makers appointed an elaborate committee of their own men, with the final result that a bottle of a somewhat different shape was recommended as a remedy, even though the difficulty may have been of chemical or bacteriological nature.

The bottle-makers' association grew and prospered. Not satisfied with bottles for wine, the association appointed representatives to sit on joint committees with makers of other kinds of containers, such as bathtubs and garbage cans, it being assumed that they had much in common. In the meantime less and less of exquisite rare wines began to be produced, and more and more of "vin ordinaire" of uniformly sour taste, sold in various fancy bottles. Finally the more discerning consumers from abroad ceased buying wine from this particular country, and warehouses became filled with empty bottles of all kinds of fancy shapes. Some of the wine growers went into other pursuits, some continued outside the association, and some began forming small professional circles of their own, very simple in external form, and devoted exclusively to real improvements in the quality of wines and general theory of grape culture and fermentation. Full membership was restricted to actual grape growers and wine makers; any one interested as an amateur could become an associate member, but bottle makers were strictly excluded. In some circles, to be admitted one even had to prove that neither of his grandfathers was a bottle maker nor related to one.

In the end the cycle was completed and the wine growers again acquired the prominence due them, while the bottle-makers' association became too top-heavy to continue to exist. Individual bottle makers found their proper modest function furnishing simple reliable bottles as specified by the wine makers. From the temporary flare-up, when the bottle makers came near ruining the wine industry by their overzealousness and naive conceit, some of the puzzling old sayings originated, such as, "tell your troubles to the bottle makers," or "try a different-shape bottle."

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[2] "Wine Makers and Bottle Makers—A Parable," by Vladimir Karapetoff, reprinted with permission from *Electrical Engineering*, December, 1934.

Machine-Shop Practice

TO THE EDITOR:

One inherent property of a broaching tool which probably has a direct relation to the extensive application of the process which is now developing is that each cutting tooth has only one kind of work to do. If it is a roughing tooth it is exclusively engaged in the preliminary cutting necessary to prepare the way for the finishing teeth. Likewise, the teeth designed for finishing never touch the heavier cuts, or scaly material in the case of castings or drop forgings. This fact is of greater importance in surface broaching than in interior broaching as it is usually feasible and advisable to make the surface broaching tools in sections, and the roughing sections can be sharpened or renewed without touching the finishing sections.

All of these facts were undoubtedly understood by the early promoters of the broaching process, who persistently advocated surface broaching many years ago. Progress in this line was doubtless retarded until the hydraulic broaching machine was available, as the screw-type machine was so inefficient and required so much maintenance that it tended to confine the use of broaching to operations for which there was no ready substitute, such as splined holes.

I am much interested in the comment[3] "that the unquestioned acceptance of the hydraulic principle for operating machine-tool mechanisms . . . . is at last waning, etc." This is good news to those of us who have for years been interested in the acceptance of the hydraulic method for those applications to which it was better adapted than any other available means. For years we were confronted with an equally unquestioned rejection of the hydraulic method until the evidence in its favor became so convincing that it

[3] See "Machine-Shop Practice," by R. E. W. Harrison, MECHANICAL ENGINEERING, December, 1934, pp. 739–740.

suddenly became the fashion. I certainly hope that in the future we may expect decisions as to type of drive in machine tools and in other classes of machinery determined "strictly by the economic and mechanical features."

As doubtless occurs during the introduction of all new methods, the advocates of hydraulic driving have not only had to discover as best they could the principles governing its most favorable application but have had persistently to overcome the reluctance of purchasers to give attention to the recommendations of the designers. Many machine-tool feeding applications have been made more or less unsatisfactory from the use of cylinders far too small to give good results, against the recommendations of the designers. Difficulties of this type have doubtless served to emphasize the inherent limitations of the hydraulic method, such as the compressibility and rebound of the oil and the effects of leakage. The net result in the long run will be a sufficient education of the using public to compare the various systems on their merits, and I personally believe that the hydraulic method will continue to fill an important part in the machine-tool field.

It is interesting to note that in this country little progress has been made in applying the hydraulic drive to the spindles of machine tools. This is probably retarded by the lack of units perfectly adapted to the service and at a commercially available price. I think we may expect to hear more about hydraulic spindle drives within the next few years.

It may not be out of place to remark briefly that hydraulic pumps and motors should be regarded not primarily as machine-tool elements, but as a system of transmitting power wherever the requirements are better met by the hydraulic method than by the electric method or other alternatives. Progress is now being made in the application of hydraulic pumps and motors for driving paper-mill machinery, printing machinery, etc. In these applications, slow and reliable inching speeds, simple and effective braking, variable speed from alternating-current supply, simplicity, and minimum maintenance of control elements are all factors considered in reaching a correct decision.

WALTER FERRIS.[4]

[4] Vice-President, The Oilgear Company, Milwaukee, Wis. Mem. A.S.M.E.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following are records of the interpretations of this Committee formulated at the meeting of November 23, 1934, and approved by the Council.

CASE No. 790

(Interpretation of Pars. P-108 and U-76)

Inquiry: When should the stress-relieving operations required by Pars. P-108 or U-76 be carried out with relation to the making of the radiographs called for by Pars. P-102*i* or U-68*i*, where the plate thickness exceeds $4^1/_4$ in.?

Reply: It is the opinion of the Committee that when the plate thickness exceeds $4^1/_4$ in., the joint should be stress-relieved when the thickness of the metal deposited in the weld is $4^1/_4$ in., before it is radiographed as required by Pars. P-102*i* or U-68*i*. Such joints shall also be again stress-relieved after the completion of the welded joint.

CASE No. 794

(Interpretation of Par. H-67)

Inquiry: Par. H-67 of the Code requires that each plate of a completed boiler shall bear the platemaker's name with brand and tensile strength. Is it necessary to transfer the platemaker's stamp to each and all of the small pieces of plate now used in many types of heating-boiler construction?

Reply: In view of developments in the designs of heating boilers, it is the opinion of the Committee that it is not necessary to transfer the platemaker's stamp to each and all pieces of plate where the small size or shape makes it impracticable. The boiler manufacturer shall be prepared to furnish satisfactory evidence, when required, that all the plate used complies with Code specifications.

CASE No. 795

(Special Case)

Inquiry: Is it permissible under the Code for Unfired Pressure Vessels to fabricate by fusion-welding a dished head of semi-ellipsoidal form too large to be made from a single plate by welding together a dished circular center or crown plate and several "orange peel" or outer plates formed to the proper curvature?

Reply: It is the opinion of the Committee that this method of fabrication complies with the Code rules provided (*a*) the center of crown plate is not larger than 50 per cent of the head diameter; (*b*) the several plates are carefully formed prior to welding so that the finished head will have the proper ellipsoidal form; (*c*) the plate surfaces are not thrown out of alignment as a result of warping due to the welding; and (*d*) the welding meets the requirements of the Code including those relating to joint efficiency and joint details.

CASE No. 796

(Interpretation of Par. P-266)

Inquiry: Is it permissible to use for handhole openings in vertical fire-tube boilers, under the requirements of Par. P-266 of the Code, a special type of square thread plug which fits into the thimble or nipple that is in turn secured into the shell plate?

Reply: It is the opinion of the Committee that special square thread plugs as described may be used under Par. P-266 for handhole openings in vertical fire-tube boilers provided the requirements of Pars. P-258 and P-268 are met, and the thimbles or nipples are so fastened that they cannot be removed in service.

CASE No. 797

(In the hands of the Committee)

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued in pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets []. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

REVISIONS

PAR. P-12. Add the following as (*c*):

c Malleable iron as designated in Specifications S-15 may be used for boiler and superheater connections under pressure, such as pipes, fittings, valves, and their bonnets for pressures not to exceed 350 lb per sq in., provided the steam temperature does not exceed 450 F.

PARS. P-332 AND U-65. Add the following as fourth section of P-332 and as (*c*) of U-65:

Those parts of a boiler (pressure vessel) requiring Code inspection and which are furnished by other than the shop of the manufacturer responsible for the completed vessel shall be fabricated by a manufacturer in possession of a Code symbol stamp and shall be inspected by a qualified inspector. The data sheets, in triplicate, covering the part or parts shall be executed by the manufacturer and the inspector in accordance with the Code requirements, and forwarded, in duplicate, to the manufacturer of the finished vessel. This partial data report, together with his own inspection, shall be the final inspector's authority to witness the application of a Code stamp to the vessel. The manufacturer who completes the vessel and the shop inspector making the final inspection shall be responsible for its meeting Code requirements. (A sample manufacturers' partial data report form appears on this page.)

PARS. P-332, L-82, H-68 AND H-120, M-20 AND U-66. Add the following:

The A.S.M.E. Boiler Construction Code is copyrighted by The American Society of Mechanical Engineers. Permission will be given by the Society to use the Code symbol designated in this Code on vessels built according to the Code and a steel stamp for applying the symbol may be purchased from the Society by any manufacturer who makes affidavit that any vessel bearing the Code symbol and his name or trademark will be fully constructed in accordance with the A.S.M.E. Code and that he will not misuse or allow others to use the stamp issued to him.

TABLES P-7 AND U-3. Add the following footnote:

For steels of a higher tensile strength than 55,000 lb per sq in., the minimum of the specified range of tensile strength of the material in pounds per square inch to be used in this table is that for the steel in its annealed condition.

SPECIFICATION S-15. To make these specifications identical with A.S.T.M. Specifications A 47-33 for Grade No. 35,018 only revise Par. 2 to read:

MANUFACTURERS' PARTIAL DATA REPORT

A Part of Boiler or Vessel Fabricated by One Manufacturer for Another Manufacturer

1. Manufactured by..
   (Name and Address of Manufacturer of Part)
2. Manufactured for..
   (Name and Address of Manufacturer of Boiler or Vessel)
3. Identification—Manufacturer's Serial No. of Part..
   Constructed According to B. P. No................B. P. Prepared by..................
4. Description of Part Inspected...
5. Shell—Length......Diameter........Thickness........Material Maker's Brand.........
6. Heads—Form........................Thickness........Material Maker's Brand.........
   (Flat, Ellipsoidal, or Dished and Radius)
7. Openings—Reinforced..........................Unreinforced..........................
   (Number and Size) (Number and Size, Including Tube Holes)
8. Seams—Riveted, Forge Welded, Fusion Welded, Brazed, or Seamless.....................
9. Riveted Longitudinal Seam..............Pitch of Rivets......Diam. of Hole....Eff....
   (Lap or Butt, Single, Double, Triple, or Quadruple)
10. Riveted Girth Seams..................Pitch of Rivets......Diam. of Hole....Eff......
    (Lap or Butt, Single or Double)
11. Results of Physical Tests of Welded Seams. Power Boiler Drums and Vessels Built Under Pars. P-101 to P-111, Inclusive, or Par. U-68.
    Joint Specimens. T. S..................Lb per Sq In.
    All Weld Metal Specimens. T. S...Lb per Sq In.
    (If Thickness of $^{5}/_{8}$ In. or More)
    Elong. Per Cent........Free Bend Test. Ductility Per Cent..........Sp Gr.............
12. X-Ray Technique. Is a definite record of X-Ray Technique for this vessel on file with the manufacturer?..
    Were the X-Ray films examined and found to be in accordance with Code requirements?...
13. Vessels Built Under Pars. U-69 and U-70. Give date of last qualification test of each welder of parts coverd by this report..
    Were qualification tests found acceptable for this class of vessel?......................
14. Max. S. W. Pressure..........Hyd. Test..........Max. Oper. Temp...................
    Joint Unit Working Stress..............................F. S........................
15. We certify the above data to be correct and that all details of material, construction, and workmanship of the object conform to A.S.M.E. Code requirements for..............
    ....
    (Power Boiler Drum or Unfired Pressure Vessel Built Under Pars. P-101 to P-111, or U-68, U-69, or U-70)

Date................19.... Signed...
(Manufacturer)

....
(Representative)

..................................Inspector

Commission No...........................
(State or Natl. Board)

2. *Tension Tests.* *a* The tension-test specimens specified in Par. 4 shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb per sq in.	53,000 [50,000]
Yield point, min., lb per sq in.	35,000 [32,500]
Elongation in 2 in., per cent	18.0 [10.0]

b The yield point DEFINED AS THAT LOAD UNDER WHICH THE SPECIMEN HAS AN ELONGATION IN 2 IN. OF 0.01 IN., may be determined by the drop of the beam OR HALT IN THE GAGE of the testing machine, or by the divider method.

PARS. H-43 AND H-96. Revise to read: (*See next column*)

TABLE P-5 REVISED:

TABLE P-5 MAXIMUM ALLOWABLE WORKING PRESSURES FOR STEEL OR WROUGHT IRON TUBES OR FLUES FOR FIRE-TUBE BOILERS, FOR DIFFERENT DIAMETER AND GAGES OF TUBES, CONFORMING TO THE REQUIREMENTS OF SPECIFICATIONS S-17

Outside diam. tube in., D	Minimum Gage—B.W.G. 13 $t =$ 0.095	12 $t =$ 0.109	11 $t =$ 0.120	10 $t =$ 0.134	9 $t =$ 0.148	8 $t =$ 0.165	7 $t =$ 0.180	6 $t =$ 0.203	5 $t =$ 0.220	4 $t =$ 0.238
1	420	616	770	966	...	...	...	....	....	....
$1^1/_2$	280	410	513	643	774	933	...	....	....	....
$1^3/_4$	240	352	440	552	663	800	920	1102	1240	1382
2	210	308	385	483	581	700	805	966	1083	1210
$2^1/_4$	186	274	342	429	516	622	715	858	964	1076
$2^1/_2$	168	246	308	386	465	560	644	772	867	968
3	140	205	256	322	387	466	536	644	723	806
$3^1/_4$	129	189	237	297	357	430	495	594	667	745
$3^1/_2$	120	175	220	276	332	400	460	551	620	692
4	...	154	192	241	290	350	402	482	542	605
$4^1/_2$	...	136	171	214	258	311	357	429	481	538
5	...	123	154	193	232	280	322	386	433	484
$5^3/_8$	...	...	143	179	216	260	299	359	404	450
$5^1/_2$	...	...	140	175	211	254	292	351	394	440
6	...	...	...	161	193	233	268	322	361	403

$$P = \frac{(t - 0.065)}{D} 14{,}000$$

where P = maximum allowable working pressure, lb per sq in., t = minimum wall thickness, in. and D = outside diameter of tubes, in.

TABLE L-2 Revised:

TABLE L-2 MAXIMUM ALLOWABLE WORKING PRESSURE FOR STEEL OR WROUGHT-IRON TUBES OR FLUES FOR FIRE-TUBE BOILERS, FOR DIFFERENT DIAMETERS AND GAGES OF TUBES, CONFORMING TO THE REQUIREMENTS OF SPECIFICATIONS S-17

Outside diam. tube in., D	13 $t =$ 0.095	12 $t =$ 0.109	11 $t =$ 0.120	10 $t =$ 0.134	9 $t =$ 0.148	8 $t =$ 0.165	7 $t =$ 0.180	6 $t =$ 0.203	5 $t =$ 0.220	4 $t =$ 0.238
1	466	683	854	...	...	...	...	...	...	...
$1^1/_2$	311	456	570	714	860	...	...	...	...	...
$1^3/_4$	266	391	488	613	737	888	...	...	...	...
2	233	342	427	536	645	777	894	...	...	...
$2^1/_4$	207	304	380	476	573	690	794	953	...	...
$2^1/_2$	186	273	342	429	516	622	715	857	964	1076
3	155	228	285	357	430	518	596	715	804	897
$3^1/_4$	143	210	263	330	397	478	550	660	741	828
$3^1/_2$	133	195	244	306	368	444	511	613	688	769
4	...	171	213	268	322	388	447	536	602	672
$4^1/_2$	...	152	190	238	286	345	397	477	535	598
5	...	...	171	214	258	311	357	429	482	538
$5^3/_8$	...	...	159	199	240	289	332	398	447	500
$5^1/_2$	...	...	155	195	234	282	325	390	438	490
6	...	...	142	178	215	259	298	357	401	448

$$P = \frac{(t - 0.065)}{D} 15{,}550$$

where P = maximum allowable working pressure, lb per sq in., t = minimum wall thickness, in. and D = outside diameter of tubes, in.

H-43 (H-96). Each steam boiler shall be provided with one or more safety valves of the spring pop type, adjusted and sealed to discharge at a pressure not to exceed 15 lb per sq in. SEALS SHALL BE ATTACHED IN A MANNER TO PREVENT THE VALVE BEING TAKEN APART WITHOUT BREAKING THE SEAL. No safety valve for a steam boiler shall be smaller than $^3/_4$ in., except in case the boiler and radiating surfaces are ASSEMBLED IN A self-contained UNIT. No safety valve shall be larger than $4^1/_2$ in.

PAR. U-66. Insert the following after the first sentence:

IF THE VESSEL IS TO BE OPERATED AT TEMPERATURES EXCEEDING 700 DEG FAHR, THE MAXIMUM TEMPERATURE CORRESPONDING WITH THE MAXIMUM ALLOWABLE WORKING PRESSURE SHALL ALSO BE STAMPED ON THE VESSEL.

PAR. U-77. Revise third section to read:

The maximum allowable working pressure [for the hydrostatic tests] as determined by the formula in Par. U-20 AND USED IN DETERMINING THE HYDROSTATIC TEST PRESSURES shall be that at NORMAL atmospheric temperature and based on the actual dimensions and plate thicknesses REQUIRED FOR THE PRESSURE AND TEMPERATURE THAT ARE TO BE STAMPED ON [of] the vessel.

IN CASE THE VESSEL IS NOT TO BE OPERATED AT TEMPERATURES OVER 700 DEG FAHR, THE HYDROSTATIC TEST PRESSURES SHALL BE BASED ON THE MAXIMUM ALLOWABLE WORKING PRESSURE TO BE STAMPED ON THE VESSEL.

IN CASE THE VESSEL IS TO BE OPERATED AT TEMPERATURES EXCEEDING 700 DEG FAHR, THE HYDROSTATIC TEST PRESSURES SHALL BE BASED ON THE MAXIMUM ALLOWABLE PRESSURE TO BE STAMPED ON THE VESSEL INCREASED BY THE RATIO OF THE ALLOWABLE TENSILE STRESS AT 700 DEG FAHR, FOR THE MATERIAL USED AND THE CORRESPONDING ALLOWABLE STRESS AS GIVEN IN TABLE U-3, INTERPOLATED IF NECESSARY, FOR THE MAXIMUM WORKING TEMPERATURE TO BE STAMPED ON THE VESSEL.

FOR EXAMPLE, VESSEL TO BE STAMPED 200 LB, 900 DEG FAHR, BUILT OF 55,000-LB STEEL:

ALLOWABLE STRESS AT 700 DEG FAHR..............	= 11,000 LB
ALLOWABLE STRESS AT 900 DEG FAHR..............	= 5,500 LB
MAXIMUM ALLOWABLE PRESSURE AT NORMAL ATMOSPHERIC TEMPERATURE 200 $\times$ 11,000/5,500........	= 400 LB
HYDROSTATIC PRESSURE DURING HAMMER TEST 400 $\times$ $1^1/_2$...................	= 600 LB
HYDROSTATIC PRESSURE FOLLOWING HAMMER TEST 400 $\times$ 2...............	= 800 LB

FIG. U-7. Include provision for stamping of the temperature if it exceeds 700 deg fahr.

PAR. U-64. Insert the proposed revision of the third section of Par. U-77 as the second section of Par. U-64, except that in the example make the next to the last line read: "Hydrostatic Test Pressure 400 $\times$ $1^1/_2$ = 600 lb," and omit the last line entirely.

BOOKS RECEIVED IN LIBRARY

AERODYNAMIC THEORY, a General Review of Progress under a Grant of the Guggenheim Fund for the Promotion of Aeronautics. Vol. 2, Division E: General Aerodynamic Theory—Perfect Fluids, by Th. von Kármán and J. M. Burgers; edited by W. F. Durand. Julius Springer, Berlin, 1935. Cloth, 6 × 9 in., 367 pp., diagrams, charts, tables, 20 rm. This second volume of the review of aerodynamic theory presents the general mathematical foundation of the mechanics of perfect fluids and discusses the specialized developments that are of particular importance for application to the problems of aerodynamics. Chapters are included on the basic ideas of wing theory; the theory of airplane wings of infinite span; the mathematical foundation of the theory of wings with finite span; airfoils and airfoil systems of finite span; problems of non-uniform and of curvilinear motion; the development of the vortex system downstream of the airfoil; and the theory of the wake. There is a bibliography. The volume is the joint work of Th. von Kármán and J. M. Burgers.

ALLOYS OF IRON AND COPPER. (Alloys of Iron Research Monograph Series.) By J. L. Gregg and B. N. Daniloff. McGraw-Hill Book Co., New York and London, 1934. Cloth, 6×9 in., 454 pp., illus., diagrams, charts, tables, $5. Like preceding volumes in the series of studies resulting from the Alloys of Iron Research, this monograph aims to provide, in one volume, all the essential information upon copper-iron alloys. Metallurgists, engineers, and research workers are thus relieved from searching through thousands of periodicals. The work includes a bibliography of 399 articles, selected as most important.

L'ALLUMAGE DES MOTEURS A EXPLOSIONS PAR BOBINE D'INDUCTION. (Mises au Point Électrotechniques.) By A. Boury and A. M. Touvy. J. B. Baillière et Fils, Paris, 1934. Leather, 5 × 7 in., 274 pp., illus., diagrams, charts, tables, 35 fr. This volume reviews the subject of battery-ignition systems for internal-combustion engines in a concise, yet detailed manner. The first chapter reviews the historic development of ignition systems, discusses the conditions necessary for the ignition of explosive mixtures, and describes present-day methods. Chapter two considers the principles governing induction-coil ignition, discussing their mathematical representation and reviewing experimental work. The final chapter treats of the construction of distributers, ignition coils, etc.

A.S.T.M. TENTATIVE STANDARDS 1934. American Society for Testing Materials, Philadelphia. Cloth and paper, 6 × 9 in., 1257 pp., illus., diagrams, charts, tables; cloth, $8; paper, $7. The new issue of this valuable work contains 236 specifications, methods of testing, definitions of terms, and recommended practices covering materials of engineering, which have been tentatively approved by the society. This relates to metals, ceramic and concrete materials, paints, petroleum, insulation, textiles, etc. Proposed revisions of standards are also included in the volume.

BUDGETING. By P. Sinclair. Ronald Press Co., New York, 1934. Cloth, 6 × 9 in., 438 pp., charts, tables, $5. This book is intended to provide a comprehensive description of budgeting methods, based upon practical experience. Budgets for all the major activities of a business are presented and their construction, systematic revision, and use in management are discussed in detail. The treatment is practical throughout and supplies methods which can be adapted to businesses of every size.

CONSTRUCTION MÉCANIQUE. By J. Izart. Fifty-fourth edition. Dunod, Paris, 1935. Cloth, 4 × 6 in., 334 pp., diagrams, charts, tables, 20 fr. This pocketbook provides, at a modest price, a collection of formulas, numerical data, mathematical tables, and other information frequently needed by mechanical engineers and machinists.

DIE DAMPFTURBINENREGELUNG, Ausmittlung, Ausführung, Betrieb. By P. Danninger. Munich and Berlin, R. Oldenbourg, 1934. Cloth, 7 × 10 in., 242 pp., illus., diagrams, charts, tables, 15 rm. This volume provides a detailed theoretical and practical discussion of the governing of steam turbines, for the use of designers, builders, and operators. The necessary formulas are developed; the various methods of governing are described, and their advantages discussed. The elements of various valve gears are described and formulas developed for their design. The influence of changes in operating conditions upon governing is investigated.

DESIGN AND CONSTRUCTION OF HIGH PRESSURE CHEMICAL PLANTS. By H. Tongue. D. Van Nostrand Co., New York, 1934. Cloth, 6 × 10 in., 420 pp., illus., diagrams, charts, tables, $12. A large amount of scattered practical information, supplemented from the lengthy personal experience of the author with high-pressure apparatus, is presented in this volume. After a brief introduction, the design of high-pressure gas compressors, and the use of pressure in the purification of gases are described. Three chapters then treat of the design of pressure vessels, pipe, and fittings for service at ordinary temperatures. Methods of design suited to very high or very low temperatures are then considered. Succeeding chapters discuss the design of autoclaves and continuous high-pressure plants, and the manufacture of large pressure vessels for high-temperature service by forging and welding.

FORSCHUNGSHEFT 368. Mechanische Schwingungen im Maschinenbau. By F. Bielitz and L. Maduschka. Berlin, V.D.I. Verlag, 1934, Paper, 8 × 12 in., 30 pp., illus., diagrams, charts, tables, 5 rm. In the first paper in this number, Dr. Bielitz discusses the inversion of linear mechanical vibrating systems, and applies the results to various practical problems of damping the vibrations of machinery. The second paper, by Dr. Maduschka, is a mathematical study of the vibrations of block foundations for machinery.

HENRY LAURENCE GANTT, Leader in Industry. By L. P. Alford. Harper & Brothers, New York and London, 1934. Cloth, 6 × 9 in., 315 pp., illus., diagrams, charts, $4.50. Mr. Alford's study of a great pioneer in management gives an interesting picture of the man and an able account of his contributions to engineering. His preparation through heredity and training for his life work, his professional accomplishments and failures, and his social philosophy are considered. The book was written at the request of the Biography Committee of The American Society of Mechanical Engineers, and is a valuable addition to the history of American engineering.

INTERNAL COMBUSTION ENGINE. Vol. 2. The Aero-Engine. By D. R. Pye, with a chapter on the Aeroplane and its Power Plant, by W. S. Farren. Clarendon Press, Oxford (England); Oxford University Press, New York, 1934. Cloth, 6 × 10 in., 398 pp., diagrams, charts, tables, $7. This book discusses the problems faced by the practical designer of aero-engines and other engines of high output. The limits of engine performance, piston temperatures, lubrication, air cooling and liquid cooling, carbureters, and superchargers are considered at length, and there are chapters upon altitude and power output, fuel economy, and the two-stroke-cycle engine. Attention is concentrated upon principles throughout. The book provides the designer with an admirable summary of those results of recent research work which are of direct usefulness to him.

KONSTRUKTION UND WERKSTOFF DER GESCHÜTZROHRE UND GEWEHRLÄUFE. By W. Schwinning. V.D.I. Verlag, Berlin, 1934. Paper, 6 × 8 in., 167 pp., illus., diagrams, charts, tables, 15 rm. According to the author, thirty years have passed since a work giving a comprehensive presentation of the scientific principles underlying the calculation and design of guns has appeared in Germany. In the interval, new methods of construction have been introduced and new theories adopted, based upon research work upon materials. The present work is intended to present this new material in a convenient form. The design of guns, the wear during use, the materials, and their behavior under stress are discussed.

LA MANUTENTION MÉCANIQUE. (Collection Armand Colin, Section du Génie civil, No. 156.) By M. Legras. Librairie Armand Colin, Paris, 1934. Paper, 5 × 7 in., 220 pp., diagrams, tables, 10.50 fr. This book is intended for the user of mechanical-handling machinery rather than the designer, and aims to assist him to select the proper equipment for various purposes. The different types of conveyers, hoists, and transporters are described and some of the commoner problems of materials handling discussed.

SCIENCE OF RUBBER. (Handbuch der Kautschukwissenschaft.) Edited by K. Memmler; authorized English translation edited by R. F. Dunbrook and V. N. Morris. Reinhold Publishing Corporation, New York. Leather, 6 × 10 in., 770 pp., illus., diagrams, charts, tables, $15. Since the appearance of the German edition of this work in 1930, it has been recognized as the most comprehensive review of the science of rubber available to the research worker. This translation, prepared by various members of the staff of the Firestone Research Laboratory, not only makes the work available in English, but in addition brings it down to date by notes covering more recent developments. A bibliography of over 1700 books and pamphlets has also been

added to the translation. The volume will be indispensable to students of rubber.

SECHSSTELLIGE TAFEL DER TRIGONOMETRISCHEN FUNKTIONEN. By J. Peters. Ferdinand Dümmlers Verlag, Berlin and Bonn, 1929. Paper, 7 × 10 in., 293 pp., tables, 32.40 rm. These tables are designed for users of calculating machines who wish something more convenient than the usual seven-place tables. The six functions are given for values between zero and ninety degrees in ten-second intervals, and in addition there is a table giving cotangents and cosecants for one-second intervals between zero and 1 deg 20 sec. The tables are well printed and are arranged so that the most used functions (sine, tangent, cotangent, and cosine) are in the outside columns, where they are more accessible.

TECHNIQUE OF EXECUTIVE CONTROL. By E. H. Schell. Fourth edition. McGraw-Hill Book Co., New York and London, 1934. Cloth, 5 × 6 in., 231 pp., $2. This book discusses the problems of the executive in his relations with his subordinates and superiors, and aims to provide "a guide to executive straight-thinking." Methods for securing effective cooperation are considered in detail. This new edition is considerably enlarged.

THROUGH SPACE AND TIME. By Sir J. Jeans. Macmillan Co., New York, 1934. Cloth, 6 × 9 in., 224 pp., illus., diagrams, charts, tables, $3. This book is based on the Christmas, 1933, lectures at the Royal Institution. Sir James takes the reader on a journey throughout the universe, through space to its utmost bounds, and through time to the distant past. The history of the earth, the sun, the planets, stars, and nebulae is set forth in a fascinating way. The style is popular and most readable.

TORSIONAL VIBRATION. By W. A. Tuplin. John Wiley & Sons, New York, 1934. Cloth, 6 × 9 in., 137 pp., diagrams, charts, tables, $5.50. The purpose of this book is to give the designer of internal-combustion engines and other machines in which torsional vibrations are important, an understanding of the methods for calculating them. Those parts of the fundamentals of vibration theory which are necessary for a complete understanding of practical problems are explained in the simplest manner possible, and the procedure to be followed in the actual calculations is set forth in detail. No extensive mathematical equipment is required of the reader.

V.D.I.-72. HAUPTVERSAMMLUNG TRIER 1934, Saarkundgebung, Vorträge, Aussprachen. Berlin, V.D.I. Verlag, 1934. Paper, 8 × 12 in., 92 pp., illus., diagrams, charts, tables, 3 rm. The addresses and discussions before the seventy-second annual meeting of the Verein deutscher Ingenieure, at Treves, in 1934. The scientific and technical papers cover a variety of topics; technical history, management, welding, heat engineering, and wine growing. In addition, there are three discussions of the Saar problem.

WHAT'S GOING ON

A.S.M.E. Reemployment Program

A STUDY of the records of those listed with the Professional Engineers' Committee on Employment of New York City shows that the overwhelming majority were last employed in the capital- or durable-goods industries. They are unemployed because their positions no longer exist and they cannot return to the work for which they are best fitted until these industries are again active. The condition of these industries offers the most serious obstacle to any employment program. In spite of this difficulty, the Engineering Societies Employment Service has filled more than 5300 engineering positions during this depression (1600 in the first eleven months of 1934), of which total 25 per cent were members of The American Society of Mechanical Engineers. No complete records are available showing those placed in non-engineering and temporary positions, but the records of New York, Boston, Philadelphia, and Los Angeles show an even larger placement in the form of immediate relief.

In its entire history, the A.S.M.E. has never faced a similar situation. We have had to proceed by trial and error. As early as 1930 our members recognized the importance of stimulating the capital-goods industries as a basic step to recovery. This message was given at meetings and by talks throughout the country and by urging the early rehabilitation of factories. The report in the October, 1934, issue of MECHANICAL ENGINEERING, "Durable Goods and Unemployment," is but a culmination of these activities. This report should be read by every member of the Society, particularly those not satisfactorily employed, and should be given the widest possible circulation. It does not offer much hope for the unemployed engineer unless some drastic step is taken by the profession.

At the 1934 Semi-Annual Meeting, the A.S.M.E. Council authorized the appointment of a Special Committee on Employment to report at the 1934 Annual Meeting on "a plan for developing, controlling, and coordinating the operation of employment, relief, and other activities having a bearing on the social and economic welfare of the engineer." The committee, which has been continued by the Council, consists of J. N. Landis, executive committee chairman, A.S.M.E. Metropolitan Section; Crosby Field, who has written extensively on this subject in other periodicals; and W. A. Shoudy, formerly general chairman, Professional Engineers' Committee on Unemployment.

The committee's report was presented in December, 1934, and the Executive Committee of the Council voted to accept it for transmission to the business meeting, where it was read, and to approve the appointment of the Survey Committee hereinafter mentioned. The condensation of the report follows:

RÉSUMÉ OF REPORT

While recognizing the prime importance of immediate relief to the unemployed, the committee believes that this phase of the problem is being efficiently handled by local committees of the larger sections, but they are not losing sight of the need of even more intensive activity in this respect. They believe that the avenue of approach for the Society must be along an entirely different line. The engineer, especially the mechanical engineer, has been accustomed to find employment without serious effort. The depression has changed this and made it necessary for the individual to seek out ways and means of establishing his own worth to industries that need engineers, or to industries that should use engineers.

We cannot escape the definite conclusion that engineering opportunities must be discovered in industries not now using engineers to any great extent or reemployment among engineers may lag as business recovers. That there is such opportunity is shown by the November 12, 1934, news letter of the American Engineering Council in which 1930 census figures have been analyzed to show the distribution of engineers in the various industries of the country. This study shows a surprisingly small employment of engineers in the majority of industries and draws the conclusion that the development of technology in the backward industries is the main hope of the profession.

NEW OPENINGS FOR ENGINEERS

The Committee on Employment therefore proposes to give its attention first to carrying forward a program to discover openings for engineers not yet recognized. There can be little doubt that every existing industry can now employ additional engineers with a direct profit from such employment. These openings must be positions:

(1) That will bring an attractive financial return to the employer.

(2) That the engineer can fill advantageously.

(3) That will not interfere, for the present at least, with any one now employed.

Some studies have already been made and have brought to light interesting possibilities in unexpected industries. There are, however, two major difficulties in the placing of men in these openings:

(1) The employer must be convinced of his need by showing him the large losses

which he is now experiencing through lack of engineering assistance.

(2) The unemployed engineer must be shown the opportunities for usefulness and taught the technique of securing this opportunity for himself. He is discouraged by continuous and unsuccessful job hunting. Only a few understand the technique of job finding, but those few have at least continued to find means of support.

The article in the November, 1934, issue of MECHANICAL ENGINEERING, by Samuel S. Board, on "Finding Work" was intended to supply this technique. This article is now available in pamphlet form and has been received most favorably. But the unemployed engineer needs further help. We must help him find the openings.

The committee's plan is not new; it was proposed in 1933 to the New York Professional Engineers' Committee on Unemployment but at that time that committee's time was fully devoted to the immediate task of placing engineers in Federal work. In a modified form it was tried by the mechanical engineering department of one of our universities with 100 per cent placement by the class's own efforts.

The plan proposes the selection of one engineer (or more) from each industry to report on engineering opportunities and to specify the qualifications of the man who can satisfactorily fill the opening. These studies will be cleared nationally. The committee will endeavor to "sell" this need of engineering assistance to the industry by correspondence and otherwise. Qualified men will then be informed of the opportunities and advised how to prepare to make the application to the prospective employers.

During this past year progress has been impeded by lack of personnel, but in April, 1934, the program was explained to the Junior Group of the Metropolitan Section. Without further instruction or encouragement they organized a committee with Mr. Eugene Koenig as chairman, and have now close to completion some fourteen reports. The committee believes that these juniors have pointed the way to the success of this program.

RECOMMENDATIONS OF COMMITTEE

The Special Committee on Employment considers this the first step in its program and has recommended to the A.S.M.E. Council the following program, which was approved in December, 1934:

(1) The appointment of a Survey Committee of three members residing in the Metropolitan district to initiate this program, this committee to be enlarged as follows:

Any local section desiring to cooperate may nominate to Council an additional member who is also to become the local representative of the program. Three members from the Metropolitan district are suggested to insure quick action in cooperation with the staff.

(2) That Council direct the Survey Committee to give all possible assistance and guidance to the junior committee now functioning and to future junior committees as organized.

(3) That the Survey Committee be charged with selecting reports now prepared, mimeographing and distributing them to local sections, on request, as examples in the preparation of other reports.

(4) That membership of a section representative on the Survey Committee shall continue only during the functioning of the junior committee in that section.

Just as soon as a start is made and an organization is effected, other activities are open. Contacts can be made with industries that should use engineers more fully through the conventions and trade papers of each industry and through advertising pages where necessary.

The committee believes that the success of this venture can be accomplished better by the junior groups of the several local sections. The juniors have the incentive, the energy, and generally more time, but most of all, they approach this problem free of prejudices, unhampered by precedents, and with the courage to attempt the "impossible."

The Committee on Employment is not trying to dodge responsibility. It believes that its responsibility is guidance and encouragement. The committee's suggested program is only a part of the committee's responsibilities. It is taking the first step in an unblazed path.

GEORGE T. SEABURY

George T. Seabury Elected Secretary E.C.P.D.

GEORGE T. SEABURY, secretary, the American Society of Civil Engineers, has been elected secretary of the Engineers' Council for Professional Development. Mr. Seabury succeeds C. E. Davies, who, as the Council's first secretary, served throughout the organization period and for the first year of its operation.

Mr. Seabury is a graduate of Massachusetts Institute of Technology. He was engaged actively in engineering work, particularly in water-works construction, up to the time of his appointment as secretary of the Am.Soc. C.E. in 1925. During the War, he was Supervising Construction Quartermaster in charge of construction at several camps.

From the time of his graduation in 1902 to 1906 Mr. Seabury was engaged in several construction jobs in New York. From 1906 to 1915 he served with the Board of Water Supply of New York, working on the Ashokan project, the Catskill aqueduct, and the Kensico reservoir and dam. He was division engineer in charge of surveys, field investigations, and studies for reservoirs, dam, filters, rock tunnel, and aqueducts of the 18-million dollar water-supply project of the Board of Water Supply of Providence, R. I., from 1915 to 1917, when he entered military service.

Following the War, and until his appointment as secretary of the Am.Soc.C.E., Mr. Seabury was president of the George T. Seabury, Inc., specialists in heavy construction.

OFFICERS OF E.C.P.D.

C. F. Hirshfeld, mem. A.S.M.E., is chairman of the E.C.P.D. Other members of the executive committee, and the societies they represent, are as follows: J. Vipond Davies, Am.Soc.C.E.; F. M. Becket, A.I.M.E.; William E. Wickenden, A.S.M.E.; C. F. Scott, A.I.E.E.; H. C. Parmelee, A.S.Ch.E.; R. I. Rees, S.P.E.E.; and D. B. Steinman, N.C.S.B.E.E.

A.S.M.E. Manual of Practice

AT ITS meeting of September 22, 1933, the Executive Committee of The American Society of Mechanical Engineers voted to appoint a committee to prepare a manual of practice for mechanical-engineering design, construction, and installation.

The committee, which consisted of W. A. Shoudy, chairman, Alfred Iddles, B. F. Wood, J. M. Todd, Wynn Meredith, H. S. Philbrick, and Theodore Baumeister, Jr., acting secretary, submitted a report to the Council, in which it called attention to the growing tendency on the part of equipment manufacturers to be asked for and to offer engineering services and studies beyond the materials and equipment they are organized to furnish, and the attempt on the part of some so-called "consulting engineers" to expect equipment manufacturers to provide plans, specifications, and estimates beyond their rightful scope. It was the conclusion of the committee that these were unsound practices and should be condemned.

The committee requested the approval by Council of the procedure of publishing, from time to time, with the backing of the Council, such statements as were embodied in their report and in that way build up a series of articles which can eventually be codified, and the approval by Council of the immediate publication of the report herewith submitted.

THE COMMITTEE'S REPORT

The report, which was approved by the Council for immediate publication (see MECHANICAL ENGINEERING, January, 1935, p. 63), follows:

For a number of years there have been com-

plaints and misunderstandings regarding the overlapping of the duties and responsibilities of manufacturers, purchasers, and consulting engineers. Many of these complaints can be classed as wrong interpretations of accepted practice rather than unethical conduct. While no manual which might be framed would completely eliminate many of these practices the committee is convinced that much of the criticism which exists is due to a lack of understanding of what constitutes sound professional practice. The promulgation of a code will ultimately establish some definitions of good professional conduct and will elevate the standards of practice. Pending the framing and adoption of such a manual the committee proposes to place before the Council from time to time, statements from which it will be possible to build up a set of interpretations which may ultimately be condensed into statutory form. In the meantime these statements, it is hoped, will serve to clarify many situations on which some construction and interpretations are needed.

The statement which is offered for consideration and approval by the Council at this time is concerned, (1) with the growing tendency on the part of equipment manufacturers to be asked for and to offer engineering services and studies beyond the materials and equipment they are organized to furnish; and, (2) the attempt on the part of some "consulting engineers" to expect equipment manufacturers to provide plans, specifications, and estimates far beyond their rightful scope and which are really services which should be provided by the consulting engineer.

These practices are considered to be both bad ethics and poor economics. There is placed upon the manufacturer a burden which he cannot bear without ultimately passing the cost on to the consumer, and this cost is multiplied disproportionately by the number of bidders. The purchaser does not secure a free, unbiased opinion on the best way of meeting his needs. The consultant who resorts to this practice contributes nothing of worth either to his client or the vendor but simply adds an unnecessary cost item for brokerage duty.

The committee has come to the conclusion that this is unsound practice and should be definitely condemned.

A.P.I.-A.S.M.E. Code, Unfired Pressure Vessels for Petroleum Liquids and Gases

SINCE the publication of the A.P.I.-A.S.M.E. Code for Unfired Pressure Vessels in September, 1934, some questions seem to have arisen in the minds of those engaged in the industries which are making use of this code as to the relationship between it and Section VIII of the A.S.M.E. Boiler Construction Code. The following statement has, accordingly, been prepared by the Joint A.P.I.-A.S.M.E. Committee on Unfired Pressure Vessels:

The pressure-vessel problems of the petroleum industry, particularly in petroleum refining where relatively high pressures, high temperatures, and severe corrosion are frequently met, are such as to require special consideration. In order to provide a uniform basis for the construction and maintenance of unfired vessels used in this field, and at the same time not to disturb the uniformity brought about by the codes developed by the A.S.M.E. Boiler Code Committee, a joint committee of the American Petroleum Institute and The American Society of Mechanical Engineers was organized. This Joint A.P.I.-A.S.M.E. Committee on Unfired Pressure Vessels has now completed the first edition of the A.P.I.-A.S.M.E. Code for Unfired Pressure Vessels for Petroleum Liquids and Gases which can be obtained from The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

The code covers the design, construction, inspection, and repair of unfired pressure vessels for petroleum liquids and gases for metal temperatures not over 1000 F and for gage pressures above 15 lb per sq in. It is divided into five sections as follows:

W—Design and Construction of Fusion-Welded Vessels

R—Design and Construction of Riveted Vessels

F—Design and Construction of Seamless Forged Vessels (In course of preparation)

I—Inspection, Repair and Allowable Working Pressure of Vessels in Service

S—Material and Other Specifications.

A special feature of the joint code that merits emphasis is its inspection section and its requirement for changing operating conditions to keep stresses at or below those for which the vessel is designed, or, as an alternative, removing the vessel from service. It is obvious, therefore, that the code should be used as a whole and that vessels constructed in accordance with the construction sections should be regularly inspected in accordance with the inspection section.

Attention should be called to the fact that the A.S.M.E. Boiler Code, Section VIII, dealing with unfired pressure vessels has been adopted as the law governing the construction of certain vessels of this type in several states and that consequently vessels within the scope of this section for use in these states must be built in accordance with the Boiler Code rules. The joint code does not have such a legal status.

It is anticipated that many questions will arise with respect to the meaning of parts of the code, and also as to the scope of its application. These questions should be referred to the joint committee whose secretary is R. P. Anderson, 50 West 50th St., New York. Suggestions for improvement will also be welcomed.

Joint Committee Reports on Fuel Values

AT THE request of the A.I.M.E. the Council of The American Society of Mechanical Engineers, at its meeting, July 1 to 3, 1934 (see MECHANICAL ENGINEERING, August, 1934, p. 510), appointed the following as members of a joint A.I.M.E.-A.S.M.E. Committee on Fuel Values: E. B. Ricketts, Alex D. Bailey, E. H. Tenny, A. L. Penniman, Jr., and H. Drake Harkins.

A preliminary report of this committee signed by its chairman, G. B. Gould, was adopted at a meeting held on December 4 and was transmitted to the two societies. The report has been approved for publication by the A.S.M.E. Council and the Board of Directors of the American Institute of Mining and Metallurgical Engineers.

The report follows:

A.I.M.E.-A.S.M.E. REPORT ON FUEL VALUES

After careful consideration of the combination of qualities of coal available, the variety of plant characteristics, and the interrelation of these factors, the committee is convinced that it is impossible to set up any scale of values, or to devise any formula for general application which will accurately reflect the relative values of different coals for steam generation.

A list of some of the factors to be considered, such as is appended to this report and which is to be used as a basis for the organization of the future work of this committee, is sufficient to reveal the impossibility of assigning definite values to any one or combination of coal qualities. Coals which are alike in all other respects may be evaluated according to the Btu, but when they differ in any important physical characteristic the relative Btu value must be modified according to the effect of those differences, on the performance of individual plants.

For example, high fusing point of the ash is frequently a factor of value in the hand- or stoker-fired furnace, but a disadvantage in the slag-bottom pulverized-coal furnace. In hand-fired or stoker-fired plants, the economic value of the fusing point will depend, among other things, upon the rate of combustion, which in turn is dependent upon the ratio of grate area to heating surface and the load requirements of the particular plant. And further, in two plants identical in these respects, the limiting fusing point will vary with the size and type of furnace.

In addition to this, one coal quality may modify or offset the effect of another one. There is at least the possibility that differences in size and coking qualities of two coals and the chemical composition of their ash may modify clinker formation to such an extent that the coal having the lower fusing point will result in more satisfactory performance.

The physical and chemical properties of coal may affect: (1) The efficiency of the plant; (2) the operating cost; or (3) its capacity. Without attempting to exhaust the innumerable combinations of conditions, but by way of further example of the impossibility of assigning generally applicable values, the variability of the financial effect of capacity limitations may be cited. Of two plants, limited in capacity by coal quality, one may be able to overcome this limitation by relatively minor changes in equipment, while the other has no alternative but the addition of a complete steam-generating unit. Obviously, the value of another coal which would make either of these capital investments unnecessary is much greater in one case than in the other. Similarly, of two plants, both of which find it necessary to install additional steam-generating units as an alternative to the use of coal having different qualities, one may be confronted with serious space limitations, which are extremely costly to overcome, while the other may have space available for additional units in the existing boiler house.

Taking another coal quality—grindability—the value of this factor to two plants, both using pulverized coal, may be quite different. One plant, operating at the limit of capacity of its mills, will find that a difference of ten or fifteen per cent in grindability requires a substantial capital investment. To the other plant, with spare mill capacity, this same difference in grindability involves only an increase in the direct cost of grinding.

One effect of the quantity of ash on operating costs will vary widely among plants. One plant may, at times, sell its ashes, while another will have to pay a relatively high cost per ton for removal.

While these and many similar considerations have led this committee to the conclusion, already stated, that no definite values can be assigned to individual coal qualities for steam-generating purposes, the committee is of the opinion that there is an opportunity for much constructive work in the collection, organization, and interpretation of *experience* data, which will assist the individual consumer to establish his own scale of values to suit his particular circumstances, and be helpful to the coal industry in the preparation of coal to meet a wide variety of consumer requirements.

The committee will study, on the basis of practical operating experience, the relation of individual coal qualities to the plant conditions which they affect in order to establish, where possible, the limits within which, under certain conditions, specific coal qualities may affect efficiency, operating costs, and capacity; and to suggest methods by which the individual consumer can arrive at his own scale of values.

Some of the factors which should be considered, and to which additions may be made as the work progresses, are shown on the appended list.

SOME OF THE FACTORS TO BE CONSIDERED IN COAL VALUATION

I—Physical and Chemical Properties

(1) British thermal units (as shipped and as fired)
(2) Moisture, per cent
(3) Ash, per cent
(4) Sulphur, per cent
(5) Volatile, per cent
(6) Hydrogen
(7) Fusing temperature of the ash
(8) Size
(9) Grindability
(10) Friability
(11) Coking characteristics
(12) Chemical composition of ash
(13) Character of clinker formation
(14) Ignition rate
(15) Uniformity or variability of one or more of above qualities

II—Plant Characteristics

(*a*) According to type of coal-burning equipment: (1) hand-fired, (2) stoker-fired, and (3) pulverized-coal. There are numerous variations in detail in the equipment available, under each of these broad classifications, and in addition, any two plants, though identical in coal-burning equipment, may vary in one or more of the following:

(*b*)
(1) Size and/or shape of furnace
(2) Amount and kind of water-cooling surface in the furnace
(3) Available draft
(4) Amount of heating surface exposed to radiant heat
(5) Maximum load
(6) Duration of maximum load
(7) Character of load
(8) Coal-handling and storage facilities and requirements
(9) Spare units available
(10) Competence and adaptability of boiler-room personnel.

The variables listed under (*b*) will affect furnace or fuel-bed conditions by determining:

(1) Rate of fuel feed
(2) Temperature of fuel bed
(3) Temperature of furnace
(4) Length of flame travel
(5) Heat release, Btu per cu ft furnace volume per hr.

Depending upon the particular combination of these factors in a given plant, coal qualities may limit (*a*) efficiency, (*b*) operating cost, and (*c*) capacity, as follows:

III—Efficiency

(*a*) Coal qualities may limit the efficiency of a given plant by their effect on:

(1) Loss of unburned solid fuel in the ash-pit or carried off through the boiler.
(2) Distribution of air in the fuel bed, directly affecting the percentage of CO and CO_2 in the flue gases.
(3) Loss due to hydrogen and moisture.
(4) By fouling of heating surfaces.

(*b*) The effect of coal qualities on operating cost will vary among plants, according to:

(1) Method and cost of coal and ash handling, including maintenance of coal and ash-handling equipment.
(2) Labor wage scale, and relative amount of labor required per unit of steam output.
(3) Maintenance of (*a*) grates, (*b*) furnace, (*c*) pulverizers and burners, and (*d*) fans.

(*c*) Coal qualities may affect the capacity of the plant by (1) clinkering, (2) the character of the fuel bed, (3) the rate of ignition, (4) the grindability, (5) the fouling of heating surfaces, and (6) by any efficiency limitation, or deficiency in Btu which requires the handling or preparation of quantities of coal and/or ash in excess of the capacity of handling equipment.

Labor Department to Survey Engineering Profession

AS PREVIOUSLY announced in MECHANICAL ENGINEERING, December, 1934, page 751, the Bureau of Labor Statistics is to make a survey of the engineering profession at the request of, and in cooperation with, the American Engineering Council and the engineering societies. Dr. Isador Lubin, Commissioner of Labor Statistics, under whose supervision the survey will be conducted, has issued the following statement regarding it.

DR. LUBIN DESCRIBES THE SURVEY

Checking up on the status of engineers is one of the steps toward a better understanding of the problems surrounding the professional and white-collar workers in general. Prior to this depression, these groups had not been faced with an employment crisis of any great scope or duration. Consequently, not much attention has been directed to the problems facing these people.

If any one can make immediate and practical use of statistics, it ought to be the engineers. So we are seeking to provide some of the basic figures to this group, as one of the several which need to be surveyed, in order that they may analyze their problem without any guesswork as to the actual trends and conditions.

The survey will cover roughly one-third of the 225,000 persons listed as engineers under the Census of 1930 and is intended to be a representative sample. Confidential questionnaires will supply data as to location, age, and education of individuals and their employment and earnings at stated intervals. The types of employers (whether private firms, Federal agencies, etc.) and the present duties, title, and salaries of engineers will be listed. Individuals will be asked how they seek employment—whether through private or public agencies, engineering societies, personal contact, or other means. Questions also will be included as to the licensing of engineers; whether their work is temporary or permanent, and whether under contract.

These and other questions will show how many of the engineers are unemployed and from what fields they have been displaced; how many have been forced into sub-professional or non-professional work; what has happened to salaries; and what lines, if any, are offering new employment.

This will be the most comprehensive survey of a professional group ever undertaken on a national scale. As well as helping the graduate engineers to adjust to current conditions, the findings should be of value to colleges in training new graduates for work likely to be in demand rather than along lines where there is no immediate prospect of employment. As a by-product, the survey may give some index of the volume of technological activity now under way.

In dealing with professional people, it is believed that we can secure an unusually high return as to accuracy and completeness.

Engineering organizations are keenly aware of the need for basic facts. The American Engineering Council and its member societies are cooperating with the Bureau of Labor Statistics in each step of the survey.

Edison Medal Awarded to Willis R. Whitney

THE Edison Medal for 1934 has been awarded by the American Institute of Electrical Engineers to Dr. Willis R. Whitney, "for his contributions to electrical science, his pioneer inventions, and his inspiring leadership in research."

The Edison Medal was founded by associates and friends of Thomas A. Edison, and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts" by a committee consisting of 24 members of the A.I.E.E.

The medal was presented to Dr. Whitney during the Winter Convention of the A.I.E.E., New York, N. Y., January 22–25, 1935.

Welding Conference, Lubbock, Texas, Feb. 14 and 15

THE First Annual Welding Conference on Electric and Oxyacetylene Welding will be held at Texas Technological College, Lubbock, Texas, Feb. 14 and 15, 1935.

All manufacturers and jobbers of welding equipment are invited to display and demonstrate their equipment. All persons interested in welding are invited to attend. There will be lectures, motion pictures, and demonstrations on various phases of welding. No charge will be made for the conference.

All inquiries should be addressed to Prof. H. F. Godeke, Professor of Mechanical Engineering, Texas Technological College, Lubbock, Texas.

Lubrication Transferred to A.S.M.E. Machine Shop Practice Division

THE Lubrication Engineering Committee, formerly a subcommittee of the A.S.M.E. Petroleum Division, has been trans-

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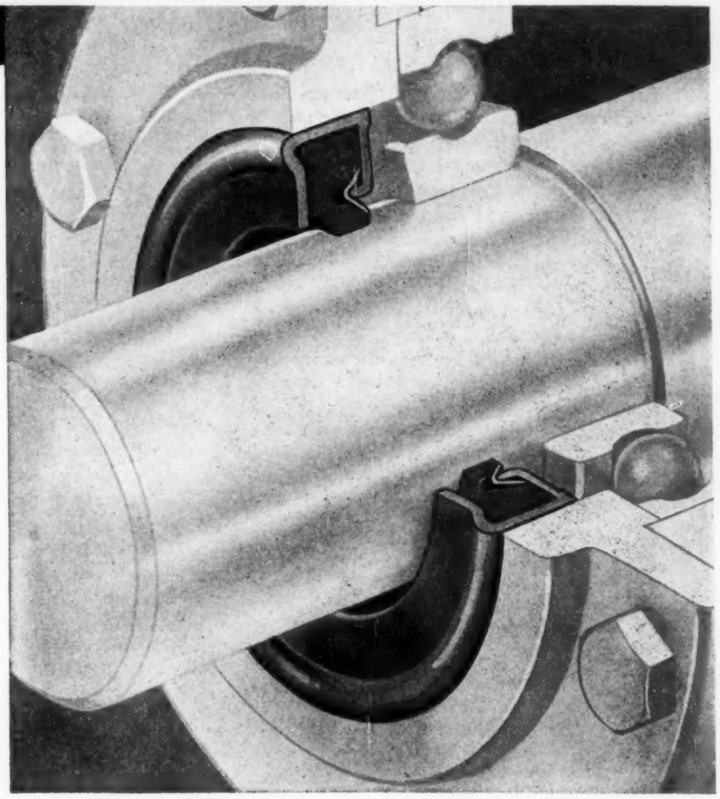

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The sealing member in the Garlock KLOZURE is not leather, cork or felt. It is made from a special compound, developed in the Garlock laboratories, and molded into a shape resembling the famous Garlock Chevron packing ring.

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ferred to a subcommittee of the Machine Shop Practice Division. The object of the transfer was a better coordination of the activity of machine designers and lubrication engineers. The Lubrication Engineering Committee has been reorganized and will consist of the following: W. F. Parish, chairman, G. B. Karelitz, H. J. Masson, C. H. Bromley, and C. M. Larson. Besides this the committee will have a large number of advisers representing the various industries and fields.

R. E. W. Harrison becomes the new chairman of the Machine Shop Practice Division for 1935, succeeding B. P. Graves. G. F. Nordenholt becomes secretary of the division. The division has active subcommittees on foundry practice, machine design, welding, and cutting of metals.

A.S.M.E. Papers Requested for Semi-Annual Meeting June 19-21

THE Semi-Annual Meeting of the Society will be held in Cincinnati, June 19–21, with headquarters at the Hotel Gibson. The chairman of local committee on arrangements is John T. Faig, president, Ohio Mechanics Institute, Cincinnati, Ohio.

The technical program for the meeting is now being arranged. Professional divisions and special committees are developing their programs and any one wishing to contribute a paper to this meeting should send it in at once.

A 250-word abstract of the paper is also required. If the manuscript is not available, the abstract should be submitted immediately, and the manuscript should follow before March 1 at the latest. An effort will be made to publish the papers to be presented at this meeting in the April and May issues of the A.S.M.E. Transactions.

A.S.M.E. Petroleum Division Names Chairman

H. F. BRINDEL becomes the new chairman of the A.S.M.E. Petroleum Division, succeeding W. D. Heltzel. The Petroleum Division has active subcommittees on production, oil transportation, gas transportation, and petroleum refining. The division also has survey committees in the Mid-Continent field working on unfired pressure vessels, pumping-station problems, and metering. The division will be represented on the Lubrication Engineering Committee, which has now been transferred to the Machine Shop Practice Division, by H. J. Masson.

A.S.M.E. Management Division Names Committees

THE A.S.M.E. Management Division announces the appointment and reappointment of its subcommittee chairmen. The division has ten subcommittees whose chairmen are as follows: A. J. Graf, D. B. Porter, M. F. Skinker, C. B. Auel, G. W. Kelsey, Kerr Atkinson, K. W. Jappe, R. Likert, A. F. Ernst, W. E. Freeland. The new chairman of the division for 1935 is Joseph A. Piaciatelli, who replaces John R. Shea, who served as chairman for 1934. W. H. Kushnick is secretary of the division.

A.S.M.E. Nominating Committee

THE 1935 Nominating Committee of the American Society of Mechanical Engineers, A. G. Christie, chairman, asks for suggestions of names of men qualified to fill the offices of president, vice-president, and manager of the Society. These names should be sent promptly to the secretary of the A.S.M.E. Nominating Committee so that they may be given thorough consideration prior to the national meeting of the Nominating Committee in Washington, D. C., sometime in May, 1935.

The selection of Society officers is an important task, and the Nominating Committee asks the cooperation of the individual members of the Society in guiding its deliberations.

Officers should be men of prominence and leadership, with time to devote to Society affairs. Previous service on committees and knowledge of Society affairs is a factor of importance. The president and vice-presidents must be of the member grade; managers may be of any grade of membership. Suggestions may be sent to the secretary of the committee, Fred H. Dorner, 1107 East Knapp St., Milwaukee, Wis.

A.A.A.S. Elects Officers

AT THE Pittsburgh meeting of the American Association for the Advancement of Science, Dr. Karl T. Compton, president, Massachusetts Institute of Technology, was elected president of the Association. Dr. Harvey N. Davis, president, Stevens Institute of Technology, member, A.S.M.E., was elected vice-president and chairman of Section M (Engineering).

This Month's Authors

RICHMOND C. NYMAN, who is research assistant in industrial relations at the Institute of Human Relations, Yale University, writes this month on union-management cooperation in introducing and administering the so-called "stretchout" at the Pequot Mills. Mr. Nyman is associated with Elliott Dunlap Smith, whose papers on the stretchout are familiar to readers of MECHANICAL ENGINEERING. Mr. Nyman has adapted his article from the recent book in which he and Professor Smith presented the facts of this interesting case. He writes from his personal experience with the case and with a background of practical contacts with factory conditions and labor problems.

John Johnston, 1935 A.S.M.E. Thurston Lecturer on the Relation of Engineering and Science, and director of research of the United States Steel Corporation, was graduated from University College, St. Andrews, Dundee, Scotland, in 1903, and worked in chemistry there until 1905. Following two years of research at the University of Breslau, Germany, Dr. Johnston came to this country as a research associate in physical chemistry at M.I.T. He served on the staff of the Geophysical Laboratory, Carnegie Institution of Washington, from 1908 to 1916. He was in charge of the research department of the American Zinc, Lead, and Smelting Co., St. Louis, 1916–1917; with the U. S. Bureau of Mines, 1917–1918; secretary of the National Research Council, 1918–1919; and professor of chemistry, Yale University, 1919–1927. He resigned his professorship at Yale to take up his present position. He has received many honorary degrees and is a member of numerous scientific and engineering societies.

M. K. Drewry is assistant chief engineer of power plants of the Milwaukee Electric Railway and Light Co. He was graduated from the University of Wisconsin in 1922 and was employed by the Allis-Chalmers Manufacturing Company for two years before entering the central-station field. Most of Mr. Drewry's work has been in connection with the Lakeside station, at Milwaukee.

C. F. Hirshfeld, chief of research, Detroit Edison Company, is too well known to mechanical engineers to need introduction. He prepared the summary of A.S.M.E. progress reports relating to the power field at the request of the A.S.M.E. Committee on Professional Divisions. His interests include all branches of engineering and applied science. To many who knew him as a professor at Cornell he is still affectionately referred to as "Prof." When the Engineers' Council for Professional Development was formed he became its chairman.

The authors of the papers on dust and occupational-disease prevention were invited to participate in a symposium on this subject sponsored by the A.S.M.E. Safety Committee because of their especial fitness to discuss phases of this subject.

F. Robertson Jones is general manager of the Association of Casualty and Surety Executives. He is also secretary-treasurer of the Bureau of Personal Accident and Health Underwriters, and secretary of the Committee of Nine on the Financial Responsibility for Automobile Accidents In 1918 he was appointed a member of the Advisory Board U. S. Bureau of War Risk Insurance. He has written extensively on historical, economic, and sociological subjects.

Albert S. Gray, M.D., was for six years attached to the office of Industrial Hygiene of the United States Public Health Service, making surveys of working environment. For the past six years he has been Director of the Bureau of Occupational Diseases, of the Connecticut State Health Department, at Hartford, Conn.

Reuel C. Stratton is supervising chemical engineer for "The Travelers," Hartford, Conn., engaged in the application of chemical engineering to insurance.

A. G. Christie, professor of Mechanical Engineering, The Johns Hopkins University, Baltimore, Md., is well known to readers of MECHANICAL ENGINEERING for his many papers on steam power plants and steam turbines.

He resigned an instructorship in Cornell University to take charge of the erection and operation of the first steam turbine built by Allis-Chalmers. In 1907 he became mechanical engineer for the Western Canada Cement and Coal Co., Exshaw, Can., but in 1909 returned to teaching, this time at the University of Wisconsin, where he remained until called to Johns Hopkins in 1914. Throughout his teaching Professor Christie has been extensively allied with engineering through his professional practice. His keen interest in younger men and his wide experience in education and professional practice fit him for the task of speaking on the business aspects of engineering.

Men Available Registered With E.S.E.S.

FROM the lists of men available for engineering employment and registered with the Engineering Societies Employment Service, 29 West 39th Street, New York, N. Y., Walter Brown, its director, has picked a few examples of mechanical engineers representing the wide variety of talent and experience that is represented by his lists.

Four *maintenance engineers* about 50 years old, one with textile-plant and three with chemical and food-plant experience.

Six *chemical-plant executive engineers*, previous salary $9000.

One *foundry engineer*, previous salary $7500.

Seven *factory managers*, ages 45 to 55, with broad experience and good records in factory and production work.

Two *materials-handling engineers*, previous salary $6000.

One *engineer of buildings and plants* of all kinds, previous salary $12,000.

Two *time-study and production engineers*, one 30 and the other 33.

Six *sales engineers;* one 45 has specialized in oil burners, one 32 has specialized in air-conditioning, one 29 in boiler waters; the others have had general experience.

One *machine designer*, about 50, experienced in special machinery.

One *machine designer*, about 34, special machinery and plant layout.

One experienced *pump designer*, about 45.

One *plant-layout designer* with experience in chemical plants and distilleries.

Of course there are many others on the lists. Branch offices of the Engineering Societies Employment Service are located in Chicago at 211 West Wacker Drive, and in San Francisco at 57 Post St.

Coming Meetings of A.S.M.E. Local Sections

Cleveland: February 14. Subject: Future of the Street Car, by C. F. Hirshfeld, Chief Research Department, Detroit Edison Co.

Houston: February 12. Assembly Room, Fourth Floor, Electric Building, Houston, Texas, at 7:30 p.m.

Indianapolis: February 19. Evening meeting of members of the Indianapolis Section. Subject: The Engineer and Social Well-Being, by Ralph E. Flanders, President of the A.S.M.E., and President of the Jones & Lamson Machine Co., Springfield, Vt.

Dayton: February 20. Evening Meeting. Subject: The Engineer and Social Well-Being, by Ralph E. Flanders.

Columbus: February 21. Evening Meeting. Subject: The Engineer and Social Well-Being, by Ralph E. Flanders.

Kansas City: February 15. Ladies' Night.

Knoxville: February meeting will be devoted to "Industrial Development." The speakers will be Messrs. Howard B. Howie and Mack Tucker, both with the TVA.

Mid-Continent: February 22. Tulsa Club Building, at 7:15 p.m. Subject: The Use of Internal-Combustion Engines for Well Pumping, by Larry Ogden, Pure Oil Co., and an engineer from the Montgomery, Phillips, Petroleum Corporation.

Milwaukee: February 20. Wisconsin Club at 8:00 p.m. Subject: Infra-Red Photography, by Leo C. Massopust, Director of Art and Photography at Marquette University, Milwaukee, Wis.

Ontario: February 14. Room C-22, Mining Building, University of Toronto, 8:00 p.m

Philadelphia: February 26. Students' Meeting. Speakers: W. L. Batt, President S.K.F. Industries, and Col. E. J. W. Ragdale, Edward G. Budd Manufacturing Co.

Schenectady: February 28. Edison Club, Schenectady, N. Y. at 8:30 p.m. Subject: Bells, by Mr. Meneely of the Meneely Bell Company.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after February 25, 1935, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the secretary of the A.S.M.E. at once.

NEW APPLICATIONS

ASIMOW, MORRIS, Berkeley, Calif.
BERKOWITZ, IRVING, Brooklyn, N. Y.
BURLINGAME, WALTER S., St. Paul, Minn.
BUSCK, PAUL G., Allentown, Pa.
CARR, HUGH R., West Englewood, N. J.
CASTELLANO, FRANK S., Hudson Heights, N. J. (Rt & T)
CLARKE, M. H., White Plains, N. Y.
COTTLE, A. P., Chicago, Ill.
DARROW, WARREN E., JR., Angola, Ind.
DORE, A. J., Chicago, Ill.
DUMAS, LUCIEN, Paris, France
DUNAGAN, CRESCENT AVERITT, Portland, Ore.
FLINK, AUGUST E., Alameda, Calif.
FORBES, J. B., New York, N. Y.
FOSTER, CHARLES C., Maplewood, N. J. (Rt)
GILBERT, HAROLD A., New York, N. Y. (Rt)
GRAY, GUY M., Greenville, Pa.
GROWDON, J. P., Pittsburgh, Pa.
HALL, RICHARD C., Berkeley, Calif.
HARDY, W. A., Larchmont, N. Y.
HARRINGTON, R. PAUL, Brooklyn, N. Y.
HORSMAN, K. W., Morristown, N. J.
JONES, J. PAUL, Taft, Calif. (Re)
MATTESON, RICHARD J., Chicago, Ill. (Re)
MCGEORGE, GERALD G., Cincinnati, Ohio
MOORE, C. HERBERT, Chicago, Ill.
MULLIGAN, PAUL B., Long Island City, N. Y.
PARKEN, EDWARD A., Butte, Mont.
PAULSON, P. E., New Westminster, B. C.
REESE, EDWIN W., JR., Cincinnati, Ohio
REID, H. P., Chicago, Ill.
SALLEY, E. M., JR., Asheville, N. C.
SIEBERT, V. W., Hutchinson, Kan.
SIEFERT, GEORGE C., New York, N. Y.
SZECHTMANN, S., Brooklyn, N. Y.
WATSON, H. D., Essex, England
WHITE, W. E., Toronto, Ontario, Canada
WILSON, LIONEL JOSEPH, Queens Village, N. Y.
WOOLER, ERNEST, Canton, Ohio
WRIGHT, ELLIOTT F., New York, N. Y.
ZINSSER, AUGUST, JR., Cambridge, Mass.

CHANGE OF GRADING

Transfers from Associate-Member
ELLIS, DAN S., Cleveland, Ohio
MYERS, FRANK M., Woodside, L. I., N. Y.
ROSE, LEONARD J., Washington, D. C.

Transfers from Junior
JANSSON, JOHN H., Woodcliff, N. J.
KENT, LAWRASON R., Baltimore, Md.
RUST, MACK D., Memphis, Tenn.
SARTORIUS, WILLIAM J., Cincinnati, Ohio
ULBERT, AUGUST, New York, N. Y.
WEISSELBERG, ARNOLD, Jersey City, N. J.

Recent Deaths

BOND, GEORGE MEADE, January 6, 1935
BOWEN, DAVID REES, December 29, 1934
DIVINE, BRADFORD H., November 24, 1934
KAREL, FREDERICK, December 8, 1934
LEFFINGWELL, WILLIAM H., December 19, 1934
LYNCH, WALTER A., September 23, 1934
MACON, WILLIAM W., January 1, 1935
MAYO, JOHN BOYLSTON, November 29, 1934
MUNCY, VICTOR E., October 26, 1934
PROSSER, THOMAS, December 23, 1934
RICKETTS, PALMER C., December 10, 1934
ROBINSON, WILLIAM, December 31, 1934
ROYLE, VERNON, December 17, 1934
THOMAS, CARROLL D., December 24, 1934

A.S.M.E. Transactions for January, 1935

THE January, 1935, issue of the Transactions of the A.S.M.E. contains the following papers:

The Elastic Properties of Steel at High Temperatures, by Guy Versé
The Calculation of the Dispersion of Flue Dust and Cinders From Chimneys (FSP-57-1), by Huber O. Croft
Cooperation Between Industrial and Public-Utility Companies in Generating Steam and Electricity (FSP-57-2), by H. Drake Harkins
A New Method of Investigating Performance of Bearing Metals (IS-57-1), by John R. Connelly
Classification of Drying, Including Graphical Analysis of Air Drying as Developed Abroad (PRO-57-1), by A. Weisselberg, Chas. W. Thomas, and T. R. Olive.